WEST COAST VENTILATION STRATEGIES

by

AVALON MECHANICAL CONSULTANTS LTD.

21 AUGUST 1990

PHASE 5

FINAL REPORT

WEST COAST VENTILATION STRATEGIES

for

CANADA MORTGAGE AND HOUSING CORPORATION
National Office
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ABSTRACT

This project, entitled **West Coast Ventilation Strategies**, was commissioned by CMHC for the purpose of evaluating various residential ventilation systems in southern British Columbia west coast applications.

In addition to general observations and conclusions concerning residential ventilation, this report presents the results of detailed monitoring of 8 different types of systems, as they were operated over two years in actual residences. Various rates of ventilation were tested.

The following items are addressed in the report:

* Local construction, climate, and lifestyle.
* Installation and operating costs.
* Builder and homeowner response to the systems.
* Indoor air quality performance.
* Advantages and disadvantages of the various systems.

The report provides an explanation of many factors which contribute to the success or failure of specific ventilation strategies.

This project was funded by the Canada Mortgage and Housing Corporation (CMHC) and BC Hydro. The views expressed are the personal views of the authors, and do not necessarily represent the views of CMHC or BC Hydro.

TABLE OF CONTENTS

Pg

1.0 EXECUTIVE SUMMARY

This report provides evaluations of the performance of various ventilation systems in actual houses. The following systems were monitored:

1. Central exhaust; negatively pressurized crawlspace.
2. Positively pressurized crawlspace.
3. Minimum BC Code requirements.
4. Aereco variable air volume.
5. Central exhaust with passively tempered make-up (Wall Pipe) in each room.
6. Central exhaust with untempered make-up (Wall Inlet) in each room.
7. Heat recovery ventilator.
8. Heat recovery ventilator with dedicated air.

Various ventilation rates were monitored. For all houses except the HRV, Aereco and Dedicated Air houses, these rates are defined by the **B.C. Building Code**; the high rate was equivalent to 0.3 air changes per hour (ACH) regulated by de-humidistat and the lower rate was defined as 0.15 ACH continuous. The HRV house was ventilated at rates common to HRV installations. The Aereco system is a variable air volume system and the Dedicated Air house was ventilated to the 0.15 ACH continuous, and according to **CSA CAN F-326**.

Strengths and shortcomings of the various systems, methods of control, and ventilation rates are analyzed.

The results indicate that many variables contribute to the effectiveness of a ventilation system. The "human" aspects of system operation and occupancy load are among the most important factors; unfortunately, these cannot be determined prior to occupancy for most new houses.

2.0 INTRODUCTION

Avalon Mechanical Consultants were retained by CMHC to act as prime consultant on the West Coast Ventilation Study, a project initiated by The Victoria Homebuilders' Association to investigate the effectiveness of various residential ventilation strategies in West Coast applications. It is a "real life" monitoring project. Conditions could not be controlled to result in a scientific comparison of systems, and the report does not purport to present objective rankings. Many interesting findings are highlighted with respect to ventilation system effectiveness, control strategies and operational factors nonetheless.

3.0 PROJECT OBJECTIVES

.1 To design, install and field-prove selected ventilation strategies which could be adopted on a uniform basis by the Victoria Home Builders' Association, B.C. Standards branch, local municipal inspectors and CMHC. Selected systems must be technically sound, cost effective, easily available, and acceptable to both builders and homeowners. Selected systems were installed and tested in "typical" new homes.

.2 To demonstrate, measure and analyze the effectiveness of each different ventilation technology. Specifically:

i. To monitor costs and builder acceptability regarding installation, warranty and maintenance of various residential ventilation systems.

ii. To monitor homeowner acceptability with regard to cost, noise level, maintenance requirements, pollution control and homeowner educational requirements.

iii. To monitor and quantify air quality and determine each system's capability of achieving pollution control with respect to both building and occupant generated pollutants.

iv. To monitor each system's performance with respect to air quality achieved when operating at different ventilation rates. For all houses except the HRV, Aereco and Dedicated Air houses, these rates are defined by the B.C. Building Code; the high rate was equivalent to 0.3 air changes per hour (ACH) regulated by de-humidistat and the lower rate was equivalent to 0.15 ACH continuous. The HRV house was ventilated at rates common to HRV installations. The Aereco system is a variable air volume system and the Dedicated Air house was ventilated to the 0.15 ACH continuous, and according to CSA CAN F-326.

v. To estimate each system's energy consumption at each air flow rate.

vi. To present and recommend at least 3 technically sound and cost effective ventilation strategies for new, residential construction.

vii. To present and recommend at least 3 technically sound and cost effective ventilation strategies for retrofit application in problem houses.

viii. To compile a file, based on case studies, which outlines residential ventilation problems and possible solutions.

4.0 BACKGROUND

4.1 Typical House Construction and Mechanical Systems

New residential construction in the southern Vancouver Island area is predominantly wood frame, single and two storey housing, resting on crawl space foundations or on slab-on-grade foundations. Crawl spaces are typically insulated around the perimeter, and heated to provide comfort to the uninsulated floor immediately above the crawl space enclosure. Alternatively, a small proportion of structures have unheated crawl spaces with insulated floors. It is required that unheated crawl spaces be ventilated to the outdoors, with protected openings sized at a ratio of 0.1 square meters ventilation per 50 square meters crawl space area. Typical slab on grade foundations are not insulated below grade. Homes with full basements are not common because of the close proximity of bedrock to the surface. Where basements do exist, it is not typical to provide any perimeter wall insulation, unless the basement is used as a living space.

Current insulation levels are typically RSI 3.5 in walls, RSI 4.9 in attics, RSI 0.9 in heated crawl space perimeter walls, RSI 3.5 in floors over unheated crawl spaces. If basements are insulated, typical insulations levels are RSI 2.1.

Windows are normally double glazed metal frame units. Better quality construction projects will include window units with a thermal break in the metal frame. Sliding windows without bug screen protection are typical and well accepted as adequate for the climatic conditions.

The air tightness of housing construction has been increasing over the past decade, and new housing is now subject to the 1987 British Columbia Building Code requirement for a continuous air barrier as defined in Subsection 9.26.5 of the 1985 National Building Code.

The energy supply for space heating is limited to oil, electricity, and wood. Forced air, oil fired furnaces were popular in the past, but electric baseboard heat has now captured the largest share of the new construction market. Forced air electric heat is unusual. Woodburning fireplaces or airtight wood stoves are common alternate heat sources. Natural gas is expected to be available on the Island by 1992.

Traditionally, ventilation air has been supplied through opening windows and by way of natural or mechanically induced infiltration. Because of the mild climate, many homes in the recent past did not include mechanical exhaust fans even in bathrooms, in favour of operable windows which provide for short term ventilation requirements. Where mechanically induced ventilation has been provided, it is limited to standard bathroom and kitchen exhaust fans.

Fireplaces have been a source of intermittent winter ventilation air because of the induced negative pressure created across the building envelope when the fireplace is operating. The typical fireplace chimney design places the uninsulated flue on an exterior wall. In this location, unless the fireplace is operating, the chimney is cold and does not provide a constant draft to assist in ventilating the home. Furthermore, since most new homes are heated with electric baseboard systems, no other chimneys are present to assist in providing a constant ventilation air exchange.

Temperature driven natural ventilation provided to newer houses is seen less than in other parts of Canada because of the mild climate. That is, the temperature difference between the interior and exterior environments is small for most of the year, and consequently "stack effect" induced ventilation is minimal. Wind induced ventilation is often reduced because of the protection provided by the trees typical to most residential areas. The older housing stock, however, was extremely leaky, as compared to the rest of the country and perhaps this has contributed to slow acceptance of newer ventilation technologies.

4.2 Ventilation Induced Problems

The combination of circumstances described above has created a housing stock of poorly ventilated homes, and homeowner perception of these problems as being the norm for this coastal climate.

Inadequate ventilation has caused structural and subassembly damage, most typically exhibited on interior surfaces as moisture damage at the ceiling/exterior wall junctions, beneath dripping window ledges, throughout bathroom interiors, and in cool, unventilated storage spaces. Deterioration of wood window frames is common.

Mold and mildew are common on window surfaces, in bathrooms and closets, most typically on cold exterior surfaces, along baseboards and in grouting around bathtubs and sinks. Mold and mildew odours are common in living levels which are partially below grade, in closets and storage areas where temperatures are low and ventilation is minimum. These types of concerns are often seen (although not exclusively) in electric baseboard houses having minimal ventilation, and can be further aggravated by high occupancy.

Downdrafting of fireplace chimneys is a common occurrence. Many of the older open door fireplace installations have been abandoned, or airtight woodstove inserts have been retrofit into these openings.

In homes without mechanical exhaust systems, ventilation during the summer months can be inadequate because of the reduction of natural infiltration. The ambient summer temperature hovers close to room temperature and there is little temperature difference to force air change through the stack effect. Wind speeds are also lowest during the summer months and less capable of contributing to natural infiltration.

4.3 Climate and Lifestyle

The Victoria area climate is described as a mild maritime climate. The normal degree days below 18 degrees celsius are 3,115. The 99th percentile design temperature is minus 7 degrees celsius. Average relative humidity in the summer months is 79 percent, and average relative humidity in the winter months is 86 percent. The heating season extends from October through April and is generally mild with considerable cloudiness and periods of rain. A full description of the local climate is attached as Appendix 1, and includes meteorological data for two weather stations; the Victoria International Airport and at the Gonzales Heights locations.

Comfort levels in the homes are often maintained at cooler temperatures, with zone heating employed to increase temperatures only in the rooms where required. This situation allows for mold and mildew growth because of the temperature and condensed humidity conditions created in the unoccupied areas of the homes.

As described above, ventilation has traditionally been accomplished by a combination of minimal mechanical exhaust systems and operable windows. The current price of oil or electric heat (equivalent to $0.05 per kilowatt hour), reduces the desirability of providing constant ventilation through open doors or windows.

The concept of continuous, controlled ventilation has had limited exposure in this market place, other than in "high-tech" houses which have utilized heat recovery ventilators to provide continuous exhaust and fresh air supply.

4.4 Generic Ventilation System Description

Ventilation systems can be categorized as neutral pressure systems, positive pressure systems, or negative pressure systems.

Neutral pressure systems consist of two fans balanced so that equal volumes of air are moving in and out of the building enclosure, and the dual fan system is not inducing a significant positive or negative pressure across the building envelope. **Heat recovery ventilators** fit into this category. The primary advantage of this ventilation strategy is that the balanced fans will not interfere with the performance of other air consuming devices such as combustion equipment.

Negative pressure systems consist of one or more exhaust fans which withdraw air from the building enclosure and induce a negative pressure across the building envelope. This ventilation strategy is most typical in Canadian and local housing. Potential problems exist due to the negative pressure induced by the ventilation systems, which can potentially create spillage of combustion gases into the building enclosure or, in severe circumstances, backdraft the chimneys of combustion devices. Negative pressure across the building envelope is considered beneficial with respect to the building shell, because relatively dry exterior air is being pulled through the wall assemblies and absorbing any excess moisture existing in the wall cavities. The systems studied herein which fall within this category are as follows:

* Negative Crawlspace
* BC Code
* Wall Inlet
* Aereco
* Wall Pipe

N.B. See section 5 for detailed descriptions of the systems studied.

Positive pressure systems consist of one or more fans which deliver fresh outdoor air to the building, thereby creating a positive pressure across the building envelope. This ventilation strategy is common in commercial construction, but not typical in residential construction. There is some concern that positive pressure across the building envelope may drive relatively wet indoor air into the exterior wall cavities and cause long term structural damage due to moisture condensation. Positive pressure systems are desirable in that they assist in establishing a positive draft through combustion appliances, and minimize discomfort associated with uncontrolled infiltration. The **positive crawlspace system** falls into this category, although the bathroom fans, Jenn-Air, central vacuum system, clothes drier and fireplace are more than capable of offsetting the positive pressure.

Air flow rates through any of the above ventilation systems fall into two generic categories:

The first of these is a **"constant flow"** ventilation rate, in which a constant volume of air is moved through the fan(s) when it is in operation. All systems studied, excepting the Aereco system, fall into this category.

Constant flow systems do not necessarily operate continuously, and could have a high and low constant flow rate which can be operator selected depending on the ventilation requirement. An example of this system is the 1985 code requirement, whereby the code calls for exhaust fans capable of moving 0.5 air changes per hour based on the interior volume of the structure. All other Canadian precedents, as outlined below, are based on a constant volume strategy. The constant air flow strategy attempts to ensure adequate ventilation through the setting of standardized air change rates which are high enough to reduce all pollutants to a tolerable level. There is a concern that the air exchange requirements set for Canadian residential buildings are excessive, and that in the attempt to reduce all pollutants to a tolerable level (including building generated and human generated pollutants), excessive ventilation energy is used and relative humidity is reduced below the optimum comfort level.

The second air flow strategy is termed **"proportional flow"** or "variable air volume," in which a varying volume of air is moved through the fan(s) according to a self regulating mechanism which senses the needs of the immediate environment and adjusts the air volume accordingly. The only system currently available utilizing this strategy is the **French "Aereco" system** which uses interior humidity levels as the controlling variable to adjust the orifice openings of exhaust grilles and air inlet grilles. The proportional air flow strategy attempts to ensure adequate ventilation through a self regulating mechanism which, in the case of the French "Aereco" system, utilizes indoor humidity as the control variable which adjusts the air change rate.

4.5 Ventilation Rate Precedents

In October 1987, British Columbia adopted the mechanical ventilation requirements of Subsection 9.33.3 of the 1985 National Building Code. This code was amended in September, 1988.

Local municipal inspectors are interpreting and enforcing this code requirement differently in different jurisdictions.

Further complicating the interpretation of the 1985 National Building code are the other ventilation precedents also operating in the Victoria building community. These include the ventilation requirements for the R-2000 Program, the B.C. Hydro Quality Plus Program, the proposed DRAFT CAN/CSA-F326-M, and the French "Aereco" proportional negative pressure system. Summaries of the ventilation requirements for each of these precedents are included in Appendix 2.

5.0 PROJECT VENTILATION SYSTEMS INFORMATION

The ventilation systems were selected according to availability, the 1985 National Building Code requirements, or other ventilation strategy precedents as outlined in Appendix 2. Builder proposed solutions to the 1985 code requirements were tested as well as commercial systems such as the HRV and Aereco systems.

In order to monitor air quality at different air exchange rates, each ventilation system (except Aereco) was operated at least two different air flow rates. Air flow rates for each system were established by measurements on site to conform with the ventilation requirements outlined in Appendix 2. The French "Aereco" system is an exception in that it was monitored at its self adjusting air flow rate only.

The design of the air distribution ducting, exhaust and inlet openings varied from system to system, based on the demands of the specific systems and the requirements for distribution as described in the ventilation precedents in Appendix 2.

A description of each selected system is presented below with a partial summary of respective findings:

1. NEGATIVE CRAWLSPACE SYSTEM:

This installation follows the 1985 National Building Code requirements and consists of standard bathroom, utility and kitchen exhaust fans, with a combined nominal capability of exhausting 0.5 air changes per hour. Makeup air was introduced to the crawlspace via open grills in the exterior walls.

Installation Cost: $360.00

Builder Acceptability: The cost aspect is positive, but the marketability is questionable due to the image of the strategy as being primitive and the association with crawlspace odours, cleanliness etc.

Homeowner Acceptability: High in this case. Heat was largely provided by wood which was obtained at below market cost. It is expected that this strategy may cause concern with energy costs in other applications.

System Load: 7,408 ft^3 of house volume / person

Ventilation Rates:
Low: 0.15 ACH continuous.
DH: 0.3 ACH controlled by a de-humidistat having a 50% RH setpoint.

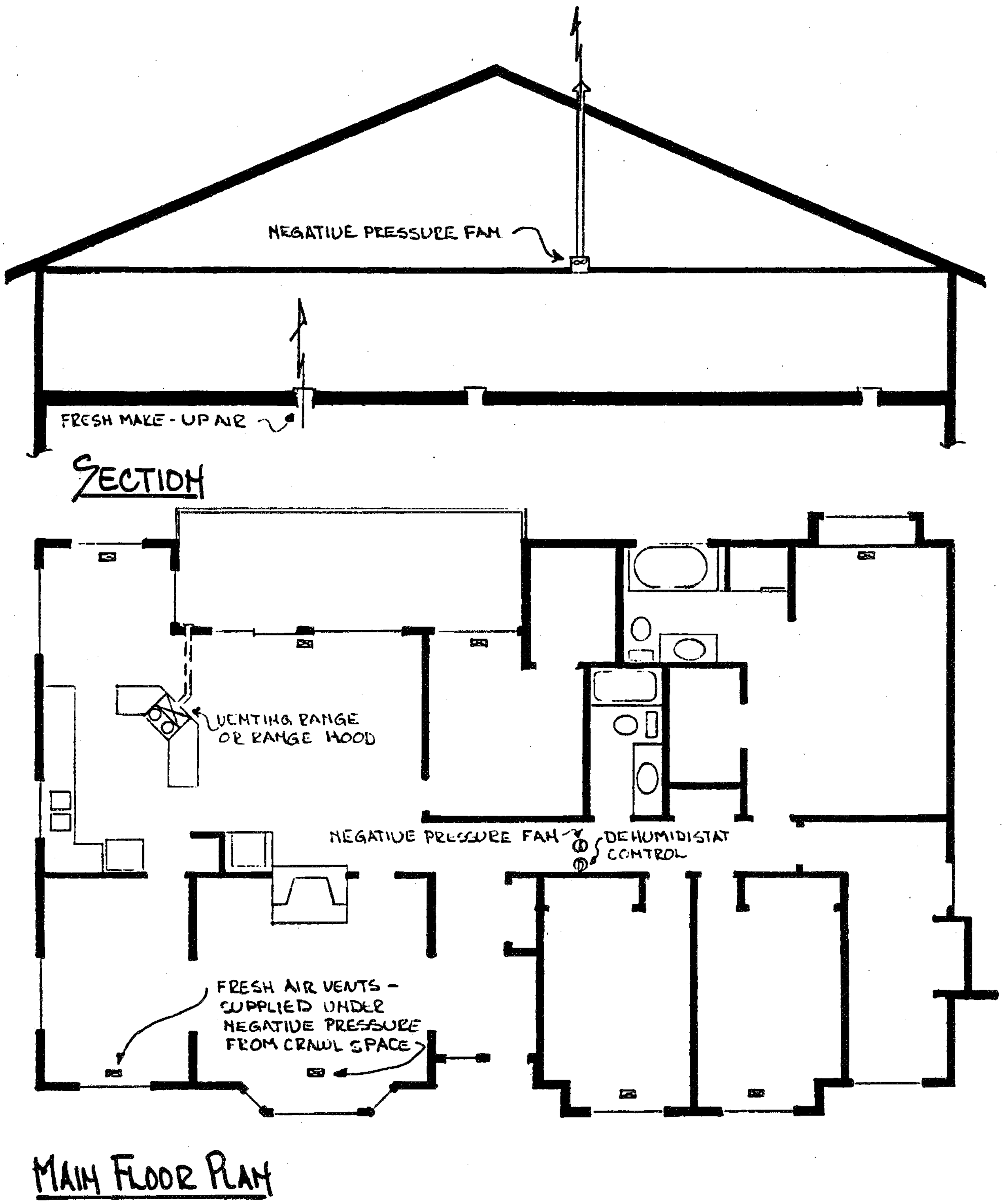
Air Quality Index: 1=poorest; 0.31=best see Appendix 3.
Low: 0.32
DH: 0.31

Energy Cost: $0.08 / ft^2 yr ; continuous at 0.15 ACH

Possible Applications: Single story, single family houses having extremely airtight upper envelopes, dry crawlspaces, high constant occupancy, adequate tempering in crawlspace, and evenly placed exhaust fans.

Shortcomings: Lack of air volume control, particularly in leaky houses. High energy costs. Combustion back-drafting must be prevented. It should be noted that emissions of radon gas are generally not considered to be a problem on Vancouver Island at this time.

WEST COAST VENTILATION STUDY



NEGATIVE PRESSURE SYSTEM C/W FRESH MAKE-UP AIR FROM CRAWL SPACE

895 HECTOR

2. POSITIVE CRAWLSPACE SYSTEM:

This installation consists of a central makeup fan discharging into the crawlspace. Open registers in the crawlspace ceiling admit air to the living space.

Installation Cost: $450.00

Builder Acceptability: The cost aspect is positive, but the marketability is questionable due to the image of the strategy as being primitive and the association with crawlspace odours, cleanliness etc.

Homeowner Acceptability: The same home was used for both crawlspace tests. The homeowner appreciated that the delivery of air was more uniform and controllable with this strategy as opposed to the negative crawlspace.

System Load: 7,408 ft^3 / person

Ventilation Rates:
Low: 0.15 ACH continuous.
DH: 0.3 ACH controlled by a de-humidistat having a 50% RH setpoint.

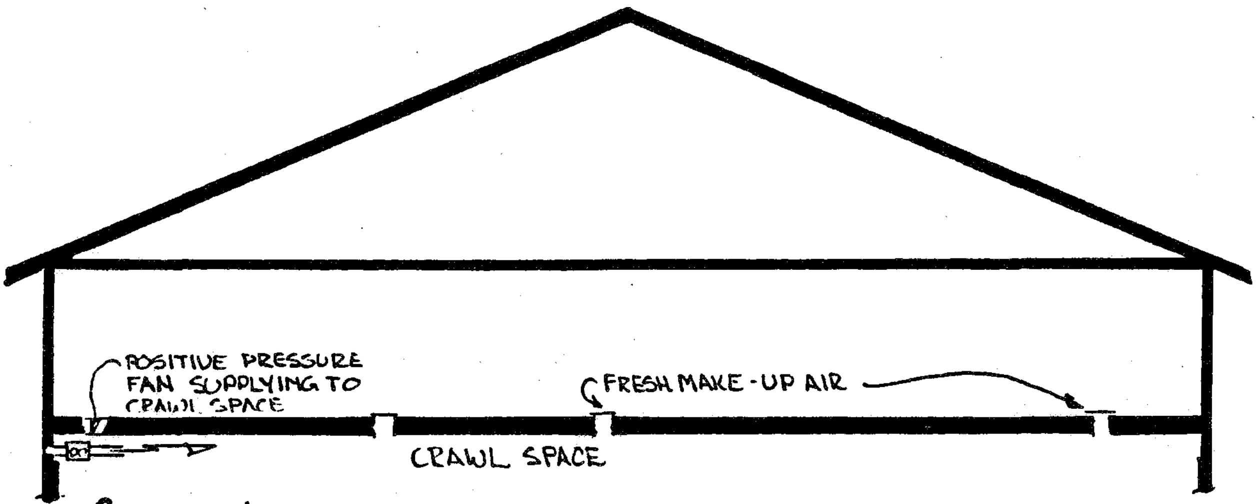
Air Quality Index: 1=poorest; 0.31=best see Appendix 3.
Low: 0.38
DH: 0.47

Energy Cost: $0.08 / ft^2 yr ; continuous at 0.15 ACH

Possible Applications: Single story, single family houses with dry crawlspaces, adequate tempering in crawlspace, proper fan location re: noise, and evenly placed exhaust fans. There are some advantages for houses having combustion appliances.

Shortcomings: Possible wall condensation in houses having high generation of moisture.

WEST COAST VENTILATION STUDY



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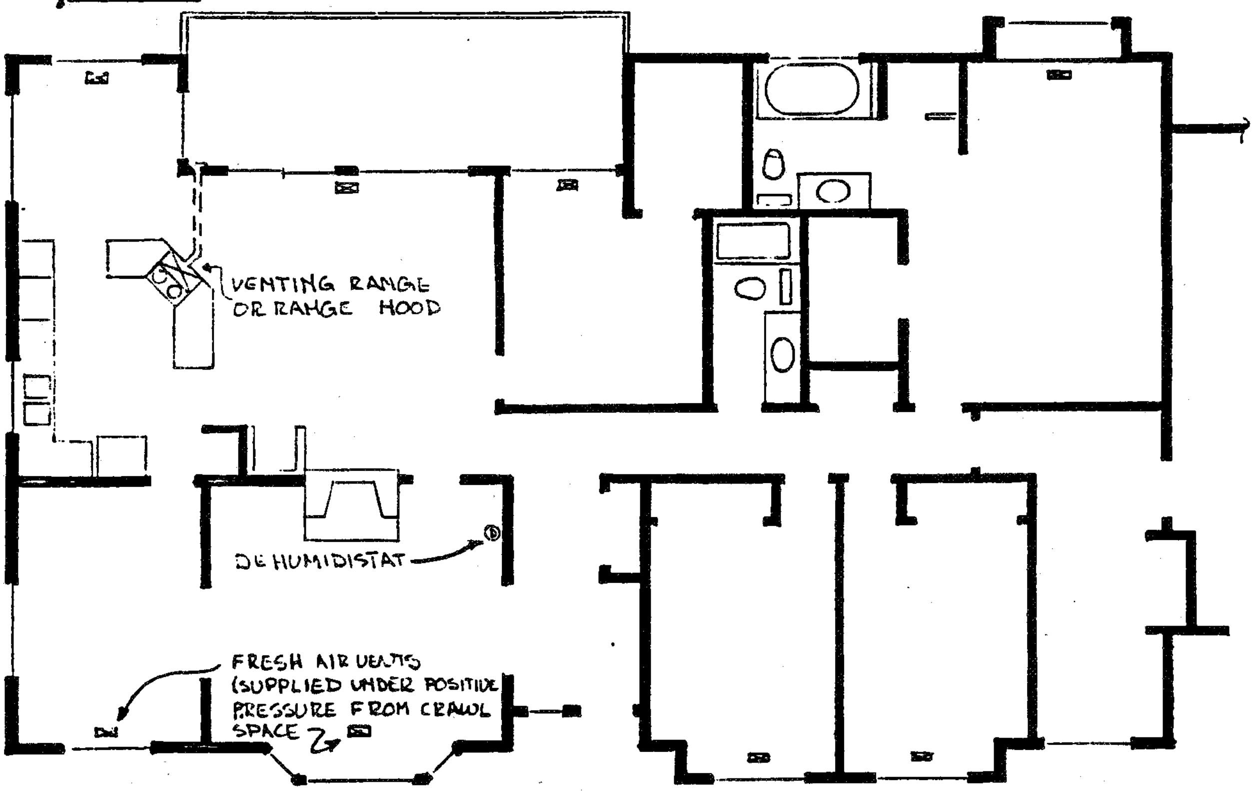


MAIN FLOOR PLAN.

CENTRAL POSITIVE PRESSURE SYSTEM C/W FRESH MAKE-UP AIR FROM CRAWL SPACE

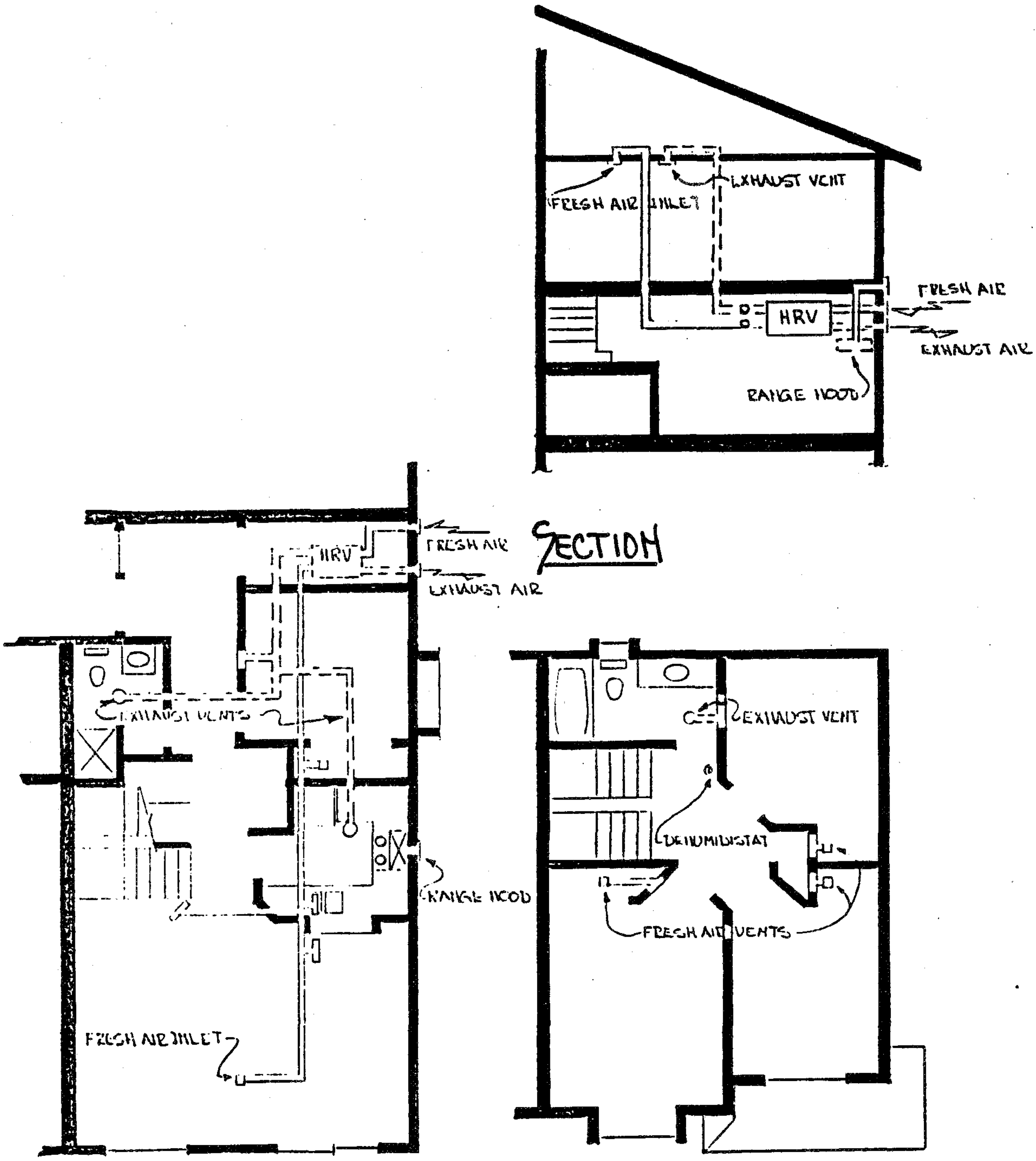
895 HECTOR

3. **HRV, (Neutral Pressure System):**

This installation consists of a commercial HRV. The minimum ventilation flow rate (50 cfm) was equivalent to 0.3 ACH. The maximum rate was equivalent to 0.7 ACH. These rates are twice the rates recommended by the B.C. Building Code, but they are realistic in view of the specifications of most commercially available HRVs.

Installation Cost:	$1,860.00
Builder Acceptability:	Acceptability has been growing as the system is perceived to be favoured by inspectors. These systems are usually installed by specialists who are seen as being somewhat responsible for IAQ in the house. HRVs are seen as a marketing plus due to an association with quality. Many installations have attic ducts and wall cavity branches which are positive from the perspective of aesthetics and space efficiency. Our poll of some 12 builders, however, indicates that half believe the system to be "overkill". The cost is seen as prohibitive by some.
Homeowner Acceptability:	The homeowner was without opinion concerning the effectiveness of this system versus any other.
System Load:	Up to 977 ft^3 / person + 12 birds in the second year.
Ventilation Rates:	**LOW**: 0.31 ACH continuous. **HI**: 0.71 ACH continuous.
Air Quality Index:	1=poorest; 0.31=best see Appendix 3. **LOW**: 1.0 **HI**: 0.64
Energy Cost:	$0.046 / ft^2 yr ; continuous at 0.31 ACH
Possible Applications:	Most houses. There are some advantages for houses having combustion appliances. Proper installation and commissioning are very important.
Shortcomings:	As with all systems studied herein, overall airflow is a fraction of forced warm air systems. Highly occupied rooms, or rooms containing above average contaminant concentrations, may not be adequately served. Filters, cores and air intakes require regular cleaning.

WEST COAST VENTILATION STUDY



MAIN FLOOR PLAN   UPPER FLOOR PLAN.

HRV SYSTEM

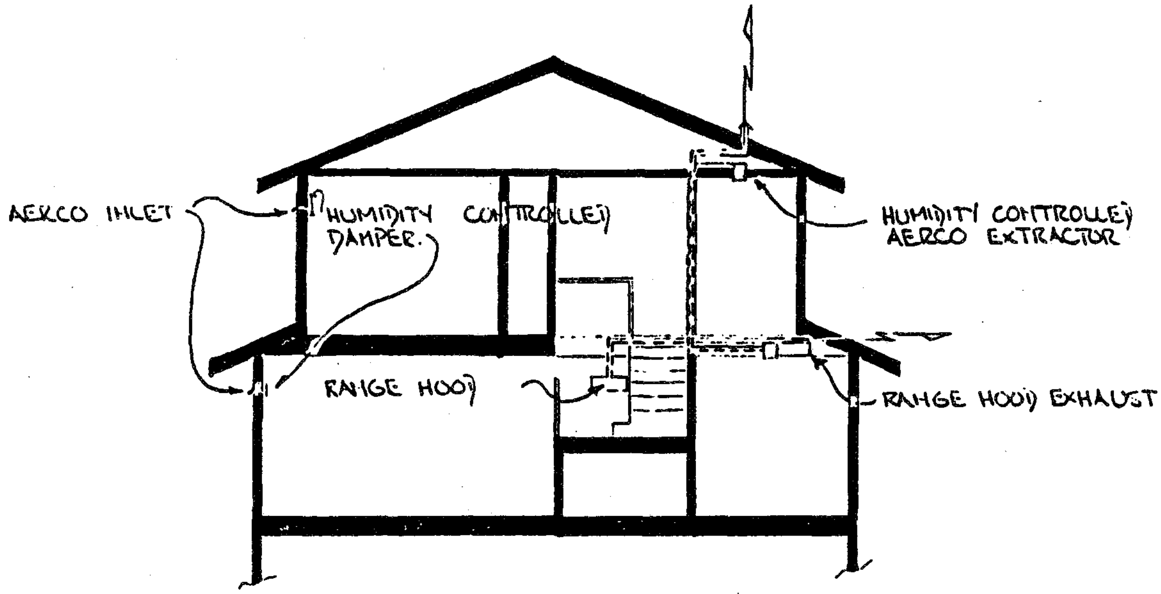
2749 JACKLIN ROAD   **UNIT 8**

4. "AERECO" Proportional Air Volume System:

This installation consists of a continuously operating central exhaust fan ducted to self-regulating exhaust air extraction grilles in the bathrooms. Makeup fresh air is introduced to the building via self-regulating inlet air diffusers which are inserted through the wall close to ceiling level. Each room has either a makeup air inlet or exhaust outlet.

Installation Cost:	$1,560.00
Builder Acceptability:	The space efficiency and perception of quality are positive aspects. Lack of familiarity with the system, combined with its relatively complex principle of operation and high price, hinder acceptability.
Homeowner Acceptability:	The homeowners were satisfied with the system and had no comments regarding its performance.
System Load:	2,733 ft^3 / person
Ventilation Rate:	approx. 0.18 ACH due to improper installation.
Air Quality Index:	1=poorest; 0.31=best; see Appendix 3. 0.74 for entire monitoring period.
Energy Cost:	$0.07 / ft^2 yr; based on cfm per %RH, and manufacturer's fan curve. Proper installation would have improved this cost.
Possible Applications:	Most houses which do not contain combustion appliances. Multi-family dwellings with conducive layouts may be economical installations. Proper installation, commissioning and maintenance are very important.
Shortcomings:	All things being equal, cooler houses will be ventilated more than warmer houses. Temperature setback energy savings can be reduced, and warm houses may not receive adequate air. Wind and stack effect can reduce ventilation to specific rooms. There is no provision for air filtration at this time.

WEST COAST VENTILATION STUDY



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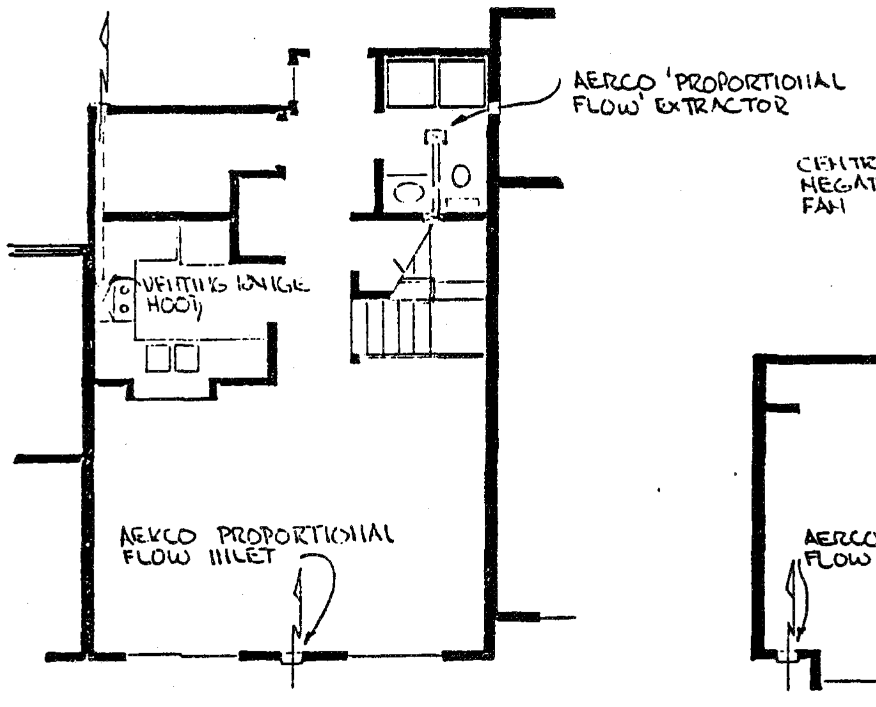
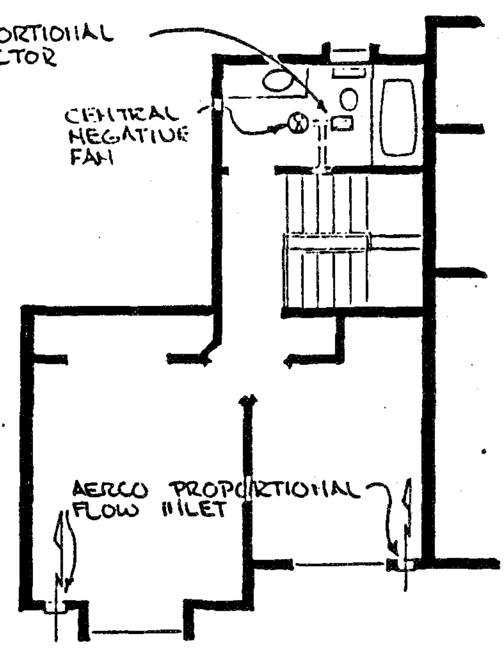


MAIN FLOOR PLAN



UPPER FLOOR PLAN

'AERCO' PROPORTIONAL FLOW SYSTEM

2749 JACKLIN ROAD

UNIT 3

5. MINIMUM BC CODE SYSTEM:

This installation consists of common bathroom exhaust fans, with a wall penetration in the living area.

Installation Cost: $450.00

Builder Acceptability: This is the most commonly installed system on Vancouver Island. The low cost is generally the most attractive aspect. Builders of custom homes often consider this strategy inadequate from a comfort, IAQ, and noise perspective.

Homeowner Acceptability: The homeowner found the house stuffy when windows were closed, and found the bathrooms to be cold and drafty.

System Load: 3,069 ft^3 / person; the house was often unoccupied.

Ventilation Rates:
Low: 0.15 ACH continuous.
DH: 0.3 ACH controlled by a de-humidistat having a 50% RH setpoint.

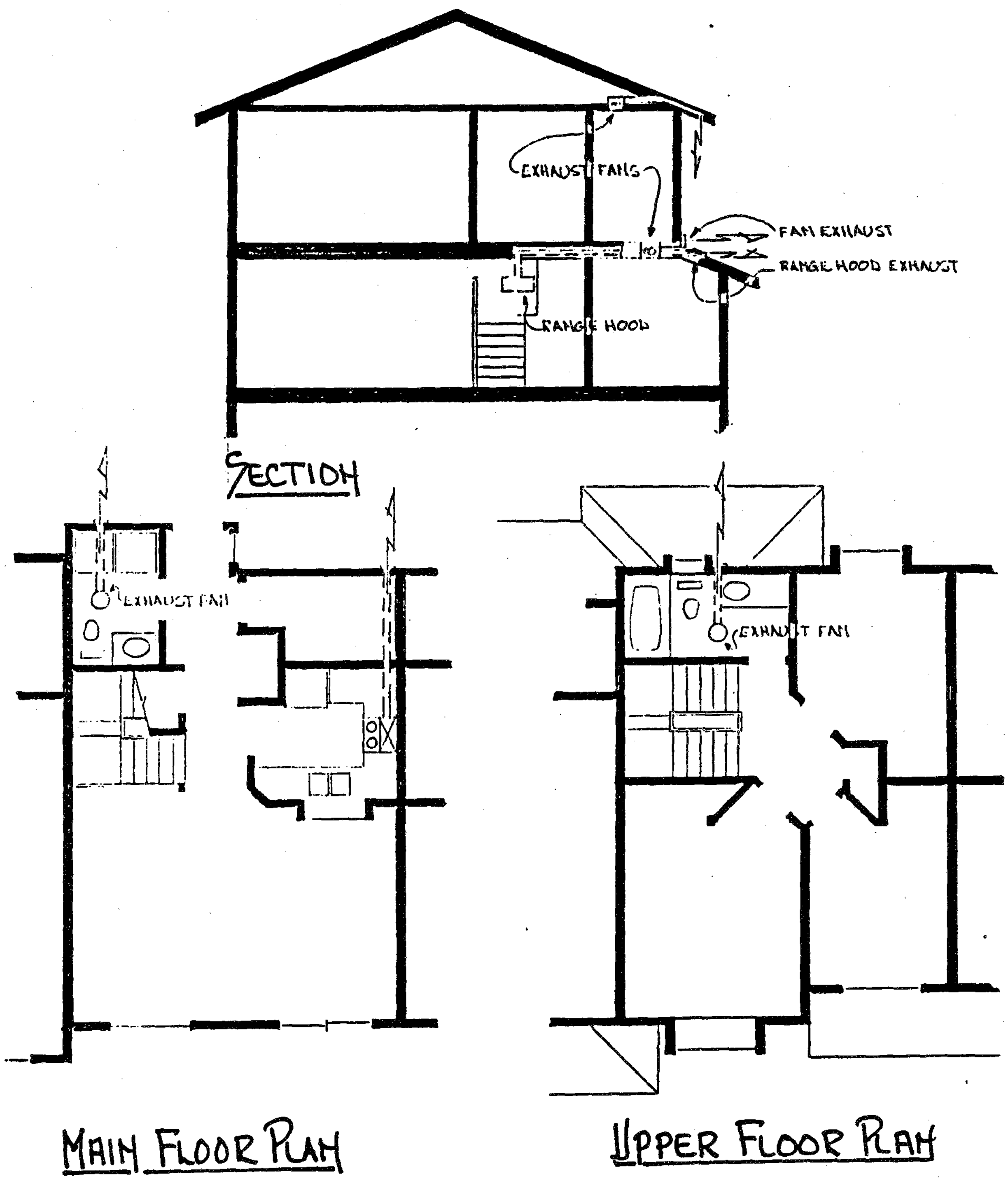
Air Quality Index: 1=poorest; 0.31=best see Appendix 3.
Low: 0.60
DH: 0.69

Energy Cost: $0.09/ft^2$ yr at 0.15 ACH continuous.
Fan wattage was much higher than that of the other systems.

Possible Applications: Large houses having low occupancy are the most applicable sites.

Shortcomings: Air distribution is seldom ensured for every room so moisture buildup, IAQ etc can be poor in areas. Fans are often noisy.
Houses containing combustion appliances often provide makeup air through a single wall penetration. If this penetration is plugged, ventilation is significantly compromised. Make-up can cause drafts. There is generally no provision for air filtration.

WEST COAST VENTILATION STUDY



B.C. CODE FAN SYSTEM

2749 JACKLIN ROAD

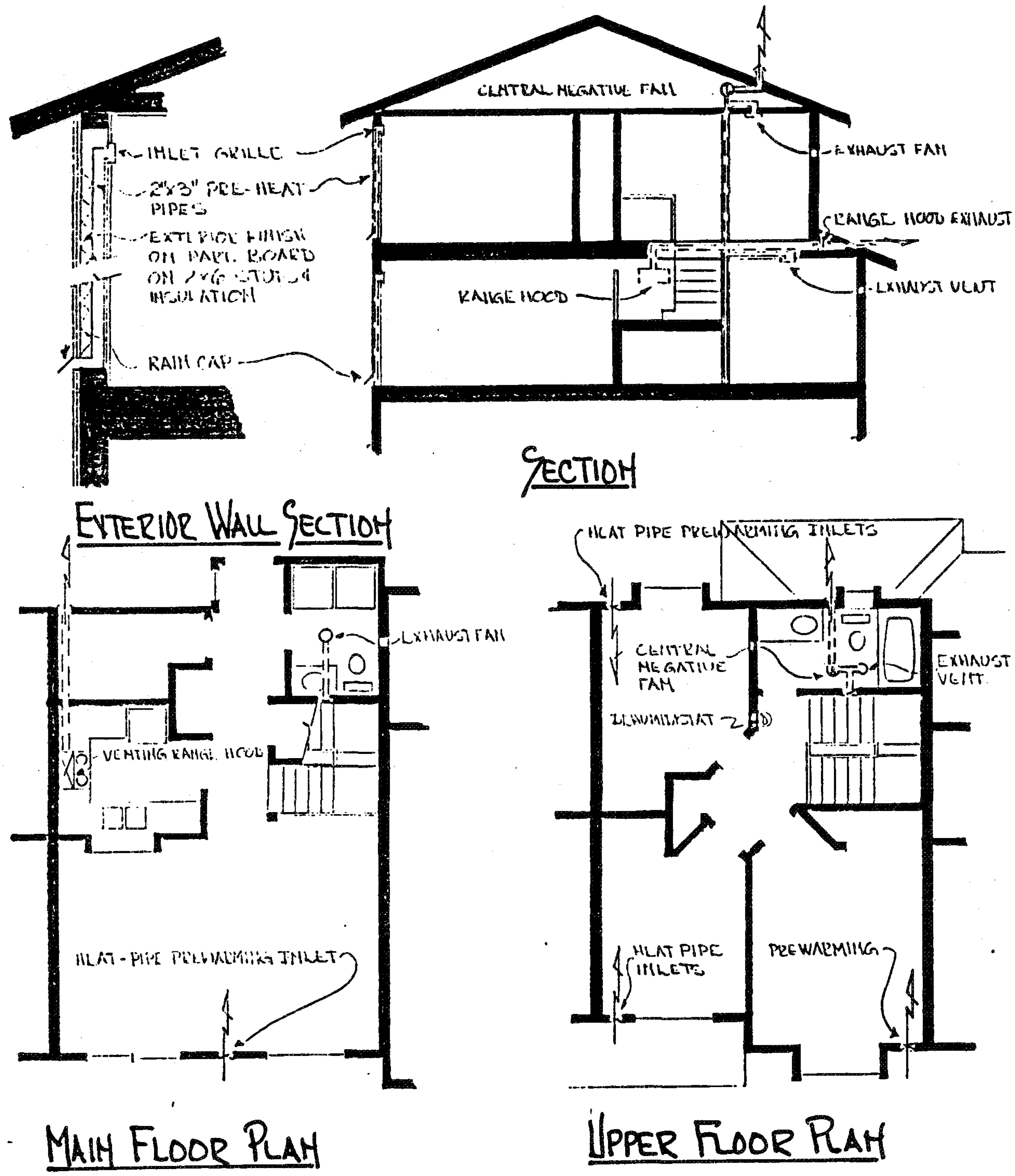
UNIT 4

6. WALL PIPE INLET SYSTEM:

This installation consists of a central exhaust fan ducted to the bathrooms. Makeup fresh air is introduced to the building via inlet air pipes. These pipes (rain water leader), duct air from the lower exterior wall to the upper interior wall level where the air is introduced into the building through a 3" equivalent diffuser. The pipes are fitted inside the insulation and outside the drywall surface in order to prewarm air before it enters the building. Each room has either a makeup air inlet or exhaust air outlet.

Installation Cost:	$600.00
Builder Acceptability:	This option is seen as being low cost, but the extra feature of the pipes is questioned by some builders.
Homeowner Acceptability:	The homeowners were satisfied with the system and had no comments regarding its performance.
System Load:	3,257 ft^3 / person
Ventilation Rates:	**Low:** 0.15 ACH continuous. **DH:** 0.3 ACH controlled by a de-humidistat having a 50% RH setpoint.
Air Quality Index:	1=poorest; 0.31=best see Appendix 3. **Low:** 0.72 **DH:** 0.76
Energy Cost:	$0.05 / ft^2 at 0.15 ACH continuous.
Possible Applications:	Large house or low occupancy house having combustion appliances and owners who are concerned with drafts.
Shortcomings:	Infiltration, and therefore energy costs, can be high. Wind and stack effect can reduce ventilation to specific rooms. Fan location is important. Air filtration is not likely to be provided for.

WEST COAST VENTILATION STUDY



CENTRAL NEGATIVE FAN SYSTEM
C/W 'HEAT PIPE' INLETS

2749 JACKLIN ROAD **UNIT 5**

7. WALL INLET SYSTEM:

This installation consists of a central exhaust fan ducted to the bathrooms. Makeup fresh air is introduced to the building via inlet air diffusers which are inserted through the wall close to ceiling level. Each room has either a makeup air inlet or exhaust outlet.

Installation Cost: $480.00

Builder Acceptability: Those concerned with the performance of the ventilation system see this as an improvement over the single penetration makeup scenario.

Homeowner Acceptability: The homeowners did not perceive any change in performance between the 2 modes of operation, but they felt that the house was stuffy when the windows were closed.

System Load: 2,733 ft^3 / person.

Ventilation Rates:
Low: 0.15 ACH continuous.
DH: 0.3 ACH controlled by a de-humidistat having a 50% RH setpoint.

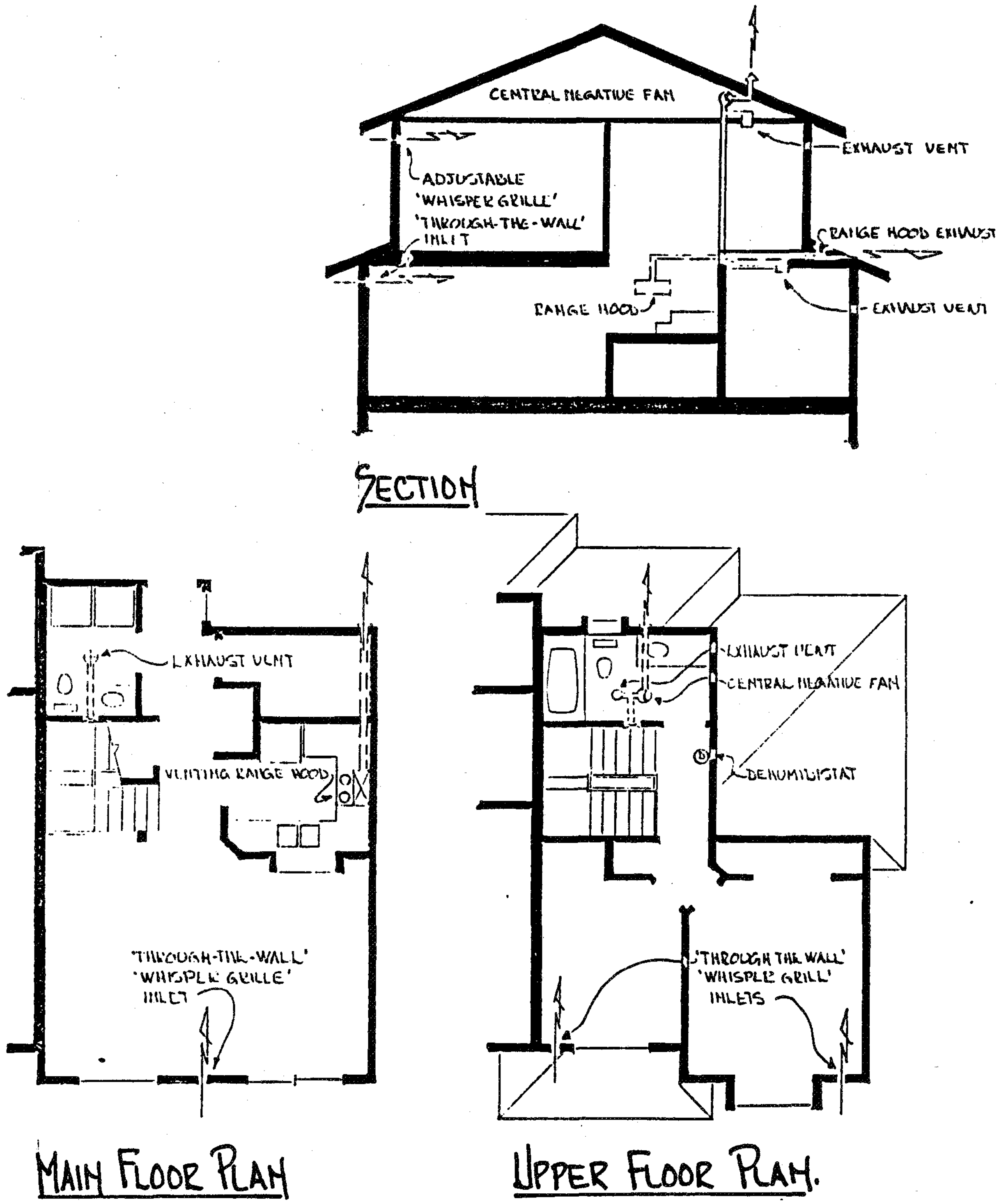
Air Quality Index: 1=poorest; 0.31=best see Appendix 3.
Low: 0.68
DH: 0.61

Energy Cost: $0.05 / ft^2 yr ; at 0.15 ACH continuous.

Possible Applications: Large house or low occupancy house having combustion appliances.

Shortcomings: Infiltration, and therefore energy costs, can be high. Wind and stack effect can reduce ventilation to specific rooms. Make-up/infiltrated air can cause drafts. Fan location is important. Provision for air filtration is unlikely.

WEST COAST VENTILATION STUDY



CENTRAL NEGATIVE FAN SYSTEM
c/w 'THROUGH THE WALL' INLETS

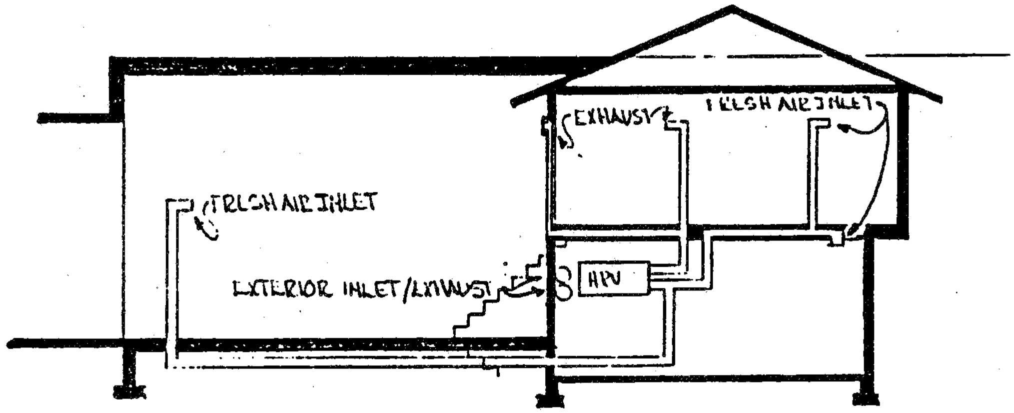
2749 JACKLIN ROAD **UNIT 6**

8. "DEDICATED AIR" SYSTEM:

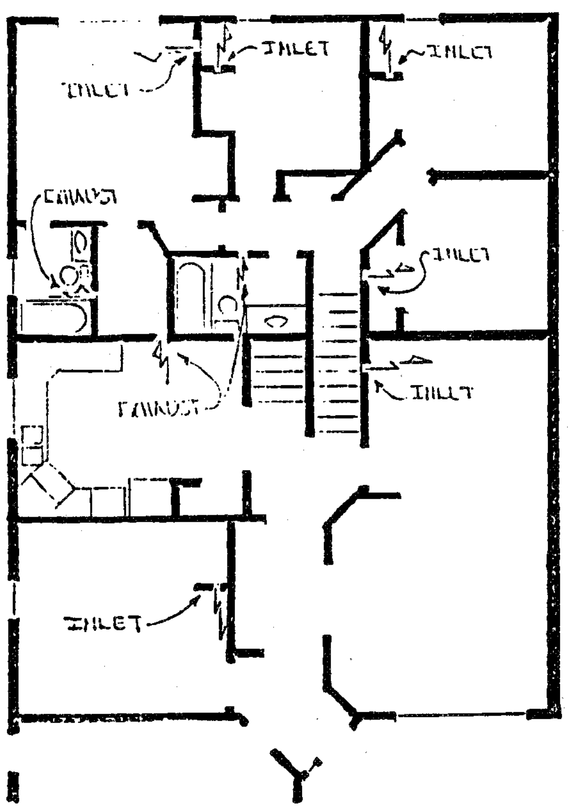
This installation consists of a standard HRV system with the capability of closing off the supply air to the living area at night (either automatically by a timer, or manually by a switch).

Installation Cost:	$2,500.00
Builder Acceptability:	This system is accepted primarily by builders who are involved and concerned with the ventilation issue. The added cost and complexity, however, serves as a deterrent in many cases. These systems are usually installed by specialists who are seen as being more responsible for IAQ in the house.
Homeowner Acceptability:	The homeowner felt that both the low and medium (low plus night dedicated air) flow rates were insufficient. He, therefore, felt that the added cost of dampers and a timeclock were not justified, particularly in view of his use of natural ventilation from windows.
System Load:	3,983 ft^3 / person.
Ventilation Rates:	**Low:** 0.15 ACH continuous. **Low + DA:** 0.15 ACH with living area air diverted to 4 bedrooms at night. **High:** 0.35 ACH continuous.
Air Quality Index:	1=poorest; 0.31=best; see Appendix 3. **Low:** 0.59 **Low + DA:** 0.64 **High:** 0.46
Energy Cost:	$0.03 / ft^2 yr ; continuous at 0.15 ACH
Possible Applications:	Houses with residents who do not frequently use their windows, and/or who enjoy technology. Superior bedroom IAQ is the feature of this system.
Shortcomings:	Added cost and complexity.

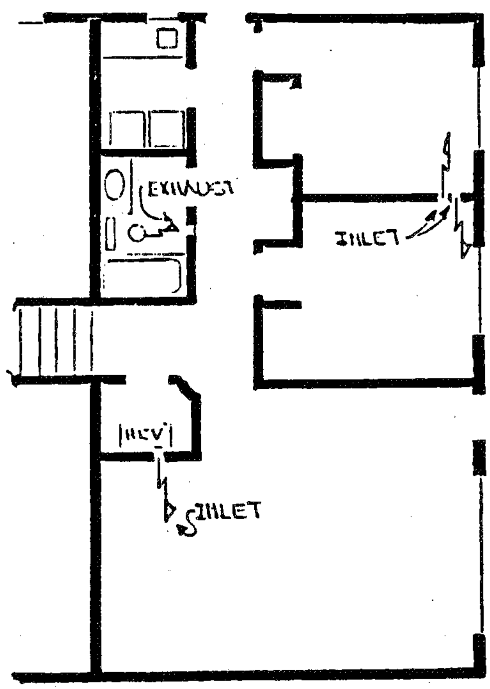
WEST COAST VENTILATION STUDY



SECTION



MAIN FLOOR PLAN



LOWER FLOOR PLAN.

HRV-DEDICATED AIR SYSTEM

4478 TORQUAY DRIVE

6.0 DISCUSSION

The following is a guide to interpreting the bar graphs contained in this section.

ABBREVIATIONS:

N.CR.	Negative Crawlspace House.
P.CR.	Positive Crawlspace House.
HRV	Heat Recovery Ventilator House.
AERECO	Aereco House.
CODE	Minimum BC Code House.
W.PIPE	House with Wall Cavity Pipes from outdoors to Room Air Inlets.
W.INLET	House with Direct Thru-wall Air Inlets in each room.
DED.AIR	Dedicated Air House.

GRAPH LAYOUT: There are 2 ventilation rates for all houses except the Aereco, which has one proportional mode of operation, and the Dedicated Air house, which has 3 modes of operation.

The graphs are arranged so that the first bar represents the data for the indicated house when the ventilation system was operating at the "low" ventilation rate (see below). The next bar to the right represents the situation at the "higher" rate.

Some graphs represent the data from the first year of monitoring, some represent the second year, and others represent both years.

VENTILATION RATES

N.CR.	LOW =	0.15 ACH Continuous.
	HIGH =	0.3 ACH Switched by 50% de-humidistat
P.CR.	LOW =	0.15 ACH Continuous.
	HIGH =	0.3 ACH Switched by 50% de-humidistat
HRV	LOW =	0.31 ACH Continuous.
	HIGH =	0.71 ACH Continuous.
AERECO	Self adjusting.	
CODE	LOW =	0.15 ACH Continuous.
	HIGH =	0.3 ACH Switched by 50% de-humidistat
W.PIPE	LOW =	0.15 ACH Continuous.
	HIGH =	0.3 ACH Switched by 50% de-humidistat
W.INLET	LOW =	0.15 ACH Continuous.
	HIGH =	0.3 ACH Switched by 50% de-humidistat
DED.AIR	LOW =	0.15 ACH Continuous.
	MED =	0.15 ACH with air diverted at night.
	HIGH =	CAN F326 (0.35 ACH) Continuous.

6.1 Test Conditions

.1 The tests were carried out in a number of houses, including 2 single family dwellings; one of which contained the dedicated air system (2nd year only), and one of which contained both crawlspace systems (1st year only). The other systems were installed in 5 attached townhouses which are owned by a non-profit society whose mandate is to provide affordable housing to native families. This society owns the units and rents them to its clients. These townhouses contained the following systems:

1. HRV
2. Aereco
3. B.C. Code
4. "Wall Pipe" Inlet
5. Wall Inlet

.2 Occupants of the townhouse units were not particularly involved in the project; the society entered into the monitoring agreement during construction and before tenancy was arranged. Some units were unoccupied during key portions of monitoring periods, windows were opened in units at random, and occupant response concerning system performance (appreciation or criticism) was very limited.

.3 The occupant of the minimum code townhouse did not sleep in the master bedroom for at least one night during its monitoring period. This was particularly unfortunate as this system was anticipated to be the least effective in providing ventilation to bedrooms. Occupancy in some other houses varied considerably.

.4 All the townhouses, except the HRV house, were monitored simultaneously. One of them (Wall Pipe Inlet) had its ventilation rates reversed ("de-humidistat" first instead of "low") as a check for trends caused by weather.

.5 Following the monitoring period it was discovered that the Aereco system had been improperly installed. The fan discharge was restricted by a 4" Whisper Grill, rather than having a 6" free discharge.

.6 Average weather conditions for the respective monitoring periods can be seen in Summary Chart of Project Results in Appendix 4.

6.2 Monitoring Results

Detailed data was collected concerning CO2, temperature, and relative humidity for each year of monitoring. Formaldehyde levels were tested for each unit in the first year and in the two units where levels were the highest in the second year. Volatile organics and microbiological contaminants were sampled in the first year of the study only. Please refer to Appendices 10 & 11 for details.

6.2.1 Indoor Air Quality Index

The overall performance of the houses, with respect to actual carbon dioxide levels, is represented by Figure 1. See Appendix 3 for an explanation of the calculation of this index.

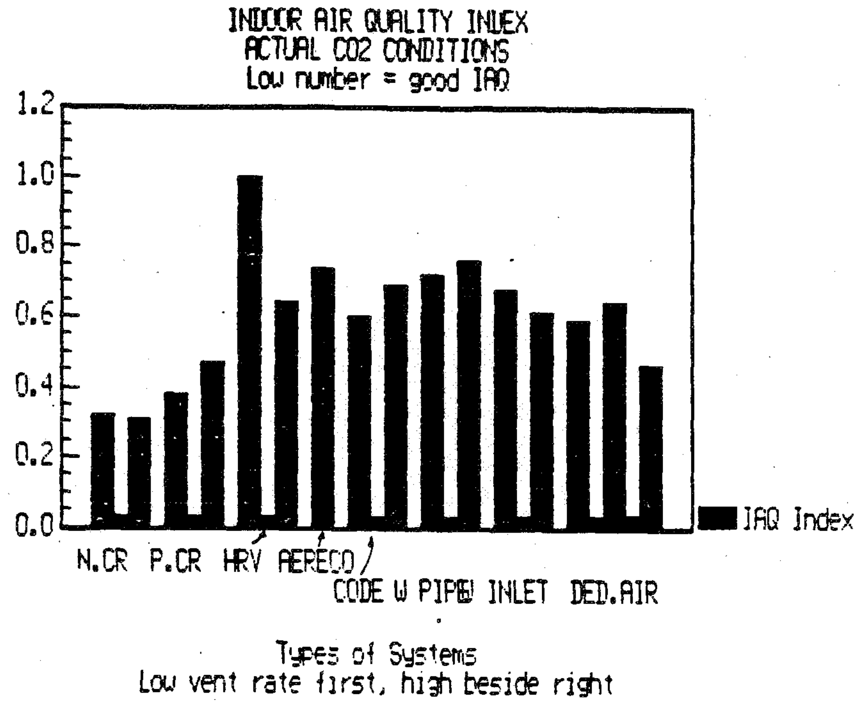


Figure 1.

The smallest bars represent the lowest CO_2 levels over the entire monitoring period.

.1 The HRV "low" ventilation rate, despite being more than twice the rate of the other houses' "low" rates, shows the highest CO_2 levels. This is due to very high occupancy (see Figure 2).

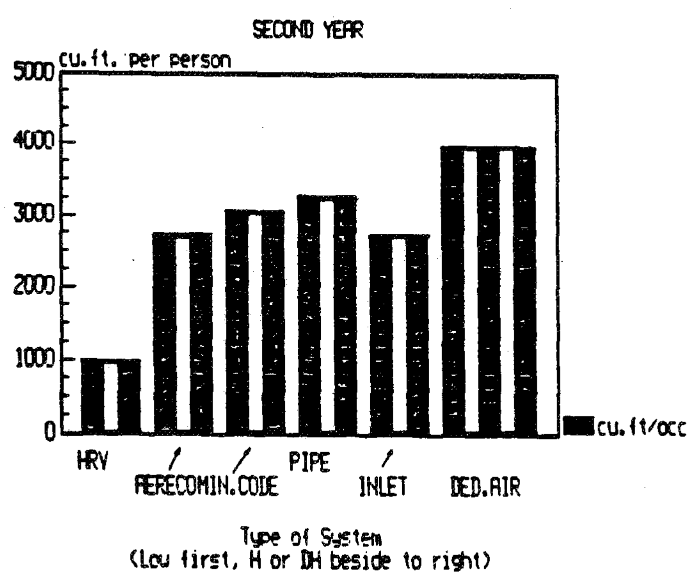


Figure 2.

.2 The "wall pipe inlet" system's high levels are largely due to the low run time of the fan during de-humidistat control. High space temperatures kept relative humidity levels lower than those of the other houses.

.3 The house containing the Aereco variable air volume system reported high CO_2 levels. It is believed that these concentrations would have been lower if the system had been installed to the manufacturer's specifications.

.4 The code house was kept considerably cooler than the other houses. This resulted in long fan run times during de-humidistat control. This house was occupied the least amount of time during the monitoring period.

.5 Average CO_2 levels exceeded ASHRAE's suggested comfort level of 1,000 PPM in seven out of the forty monitoring periods over the two year study period.

.6 The overall relative humidity levels were lower during the second year of monitoring despite higher outdoor temperatures. This may reflect diminished "house drying."

.7 Mold formed on the exhaust grills of the Aereco, "BC Code," "wall pipe," and "wall inlet" houses by the second year. Mold was starting to form on the walls of the upper bathroom in the "wall inlet" house; perhaps a result of more frequent shower use than the other units.

.8 Formaldehyde levels dropped to undetectable ranges in the "HRV" and "wall pipe inlet" houses by the second year. This tends to support the premise that outgassing declines as a building ages.

6.2.2 Carbon Monoxide

The crawlspace house was the only house which contained any kind of combustion appliance. The excessive natural ventilation of this house resulted in the decision to not monitor it for the second year. See Appendix 4 for results of first year CO spot checks.

.1 No CO problems were encountered in the crawlspace house.

.2 The reason for high CO in code house at 10:00 am on March 28, 1989 is unknown. The owner's car was in very poor repair and the driveway is directly adjacent to the front door. Perhaps car warmup was the cause.

.3 The high CO readings at the other 3 Jacklin Road units occurred during the burning of leaves by neighbours.

6.3 Mechanical Ventilation.

Figure 3 shows the rates of mechanical ventilation used for the study. These rates were set using either a thermal anemometer or a hood flow measurement device.

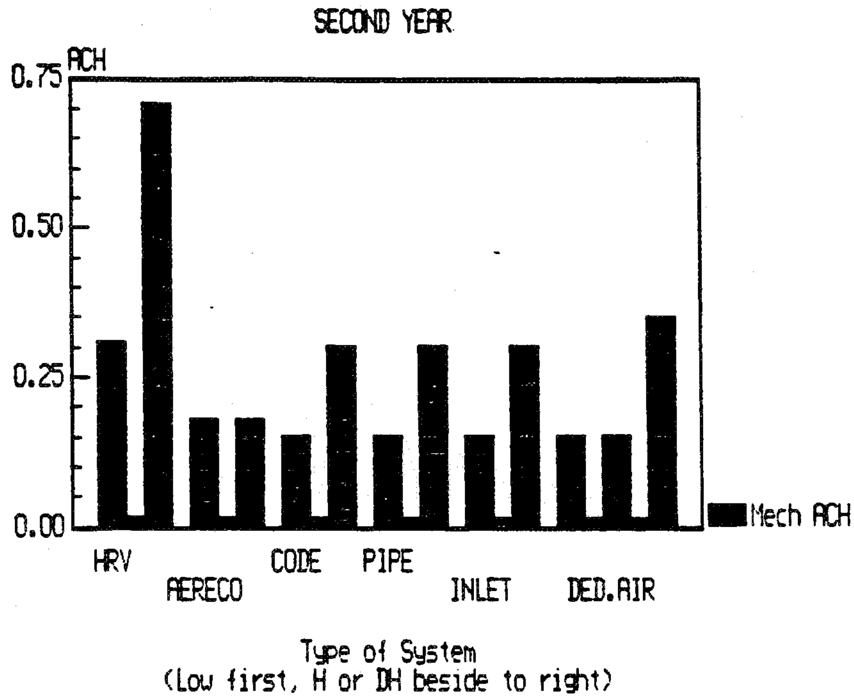


Figure 3.

.1 The "HRV" house was ventilated at rates which reflect the average performance of common HRVs rather than any specific standard. The lowest rate was more than twice the minimum code requirement, and appears to have not been adequate for the application. As previously mentioned in 4.3, high occupancy appears to have influenced the HRV's performance.

.2 The "dedicated air" house "high" speed was based upon CSA F326 requirements, which more than double the minimum requirements of the B.C. Code. The occupants found the higher rate to be acceptable, whereas the BC Code rate was unacceptable.

.3 No problems were reported concerning the tempering of makeup air. Members of the local industry, however, report that comfort problems and significant duct condensation occur in Victoria as a result of untempered makeup air.

6.4 Overall Ventilation.

.1 Almost all the houses in which tracer gas testing was performed showed overall ventilation rates which were almost twice the mechanical rate. The exception to this was the HRV house where 0.7 ACH was supposedly being supplied mechanically, but 0.5 ACH was calculated from tracer gas decay. The reasons for this exception may be tighter envelope, duct leakage and short circuiting from supply outlets to return inlets.

.2 Decay tests for the crawlspace house took place while the house was in the positive pressure configuration (with crawlspace holes sealed) and while the fan was off. This house was not tight enough to allow a blower door test; the required negative pressure could not be reached. Decay test results show very similar overall airchange for the crawlspace house (with its fan off), and the HRV house (with its fan on high speed).

.3 The Aereco system demonstrated fairly uniform air delivery. It should be noted that the ACH measured during the decay test prior to occupancy was considerably lower than that of the other houses. It was discovered at the end of the monitoring that the system was effectively operating as a constant volume exhaust system at a rate of approximately 25 cfm. The design intent was for the system to modulate between 18 and 60 cfm. The ACH calculated from the manufacturer's literature for proper operation at average actual occupied conditions was very similar to those of the other houses, but the actual mechanical airchange was approximately 0.18 ACH (55% of what would occur with a system operating as per manufacturer's specifications).

.4 The airchange in the "wall pipe" house was high, according to the decay test. Air distribution was more uniform than that of the "wall inlet" house which showed higher ACH on the lower floor than the top. It is believed that the friction resistance of pipe air flow, the resistance of cold air to rise in a pipe and the resistance of warm air to flow down a pipe may reduce the uncontrolled infiltration associated with thru-wall penetration makeup air.

.5 It was noticed that the decision to open windows in the houses was often more a result of philosophy than pollutant concentration. The "HRV" house, for example, seldom had its windows open despite the very high CO_2 levels.

.6 Figure 2 shows the amount of gross living space per occupant of the houses during the second year of monitoring. The least dense house ("dedicated air") reported that the minimum code ventilation rate was not adequate when windows were shut.

.7 Figure 4 shows that the "B.C. Code" house reported high CO_2 levels when in "low" ventilation (0.15 ACH continuous). To achieve 0.15 ACH, only one fan, located in the downstairs bathroom, was used and it had to be taped almost shut. The CO_2 sample point was in the second story hallway. Two tracer gas tests produced confusing results. It is believed that the seed gas was being drawn downstairs to the exhaust fan. This prevented uniform decay.

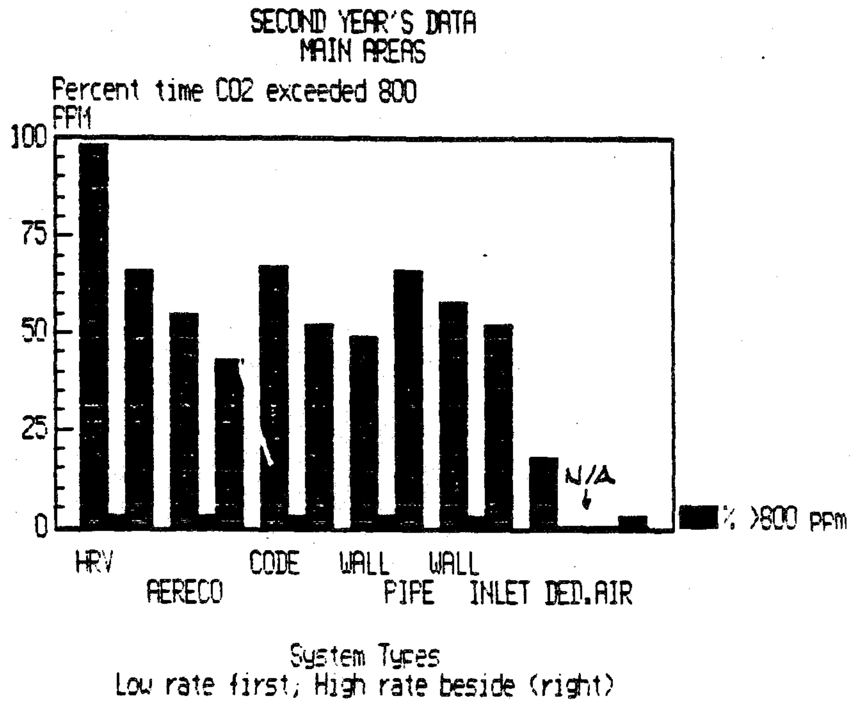


Figure 4.

.8 **Figures 1, 5, and 6 indicate that IAQ was generally better with constant ventilation than with de-humidistat ventilation in these houses. This is particularly true for warm houses.**

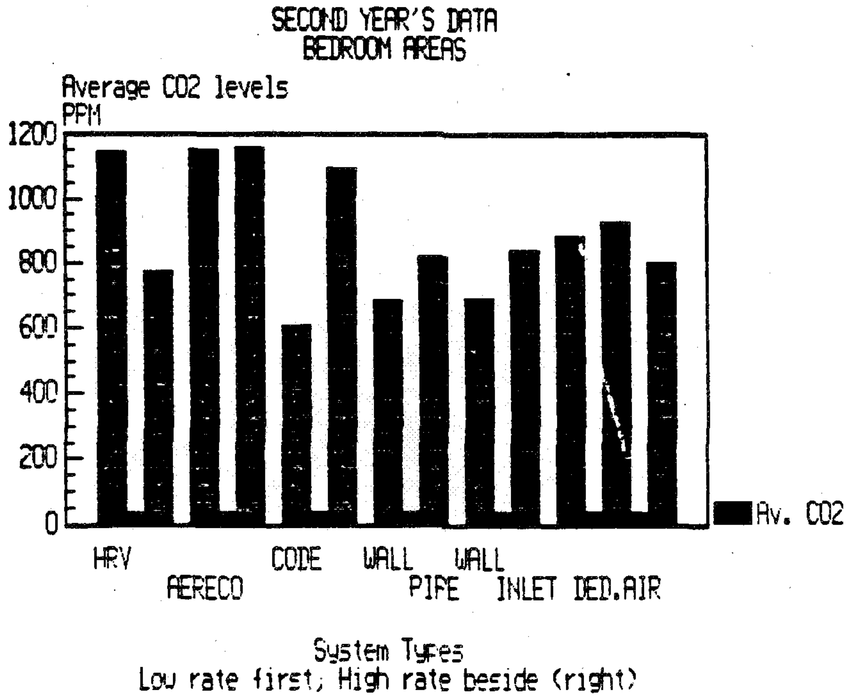


Figure 5.

6.5 Bedroom Ventilation

There is some concern that CO2 levels may be excessive at night in bedrooms of houses which are ventilated to the code standard.

.1 Theoretical calculations indicate that a 225 square foot room which receives 5 cfm per person of outdoor air will reach CO2 levels of 2,016 ppm in 8 hours.

.2 Actual peak levels exceeded 1,000 PPM in every bedroom tested, and average levels,including daytime hours, exceeded 1,000 PPM in 4 of 13 bedrooms. See Figure 6.

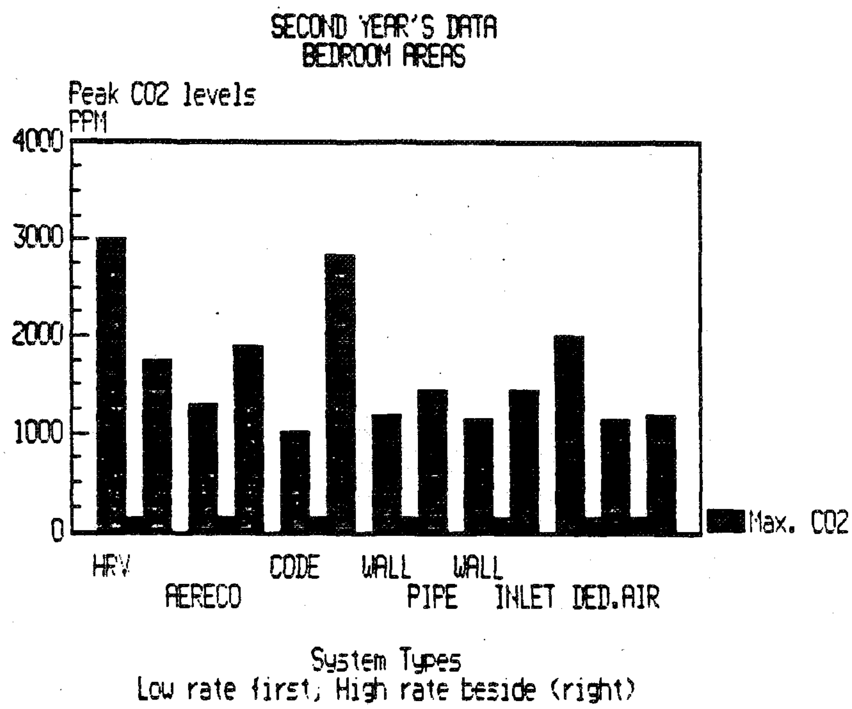


Figure 6.

.3 A further question is raised regarding multi-level houses having central exhaust fans and direct makeup air for each room through the building envelope: Are there conditions where stack and wind effect significantly reduce ventilation?

.4 Air flow measurements indicated that the bedroom of the "Dedicated Air" house received 8 cfm during minimum ventilation (0.15 ACH total house), 12 cfm when the living area was shut off at night (0.15 ACH total house), and 20 cfm under CSA F326. It should be noted that the dedicated air rate (0.15 ACH with living areas closed at night) occurred over a weekend and higher CO_2 levels are likely a result of more continuous occupancy.

6.6 Relative Humidity as Controlled Variable For Ventilation

.1 Monitoring results indicate that relative humidity can be determined more by indoor temperature than occupancy. The first year of monitoring in the "B.C. Code" and "wall pipe inlet" houses demonstrate this. The occupants of the code house preferred cool temperatures (average = 18°C) and were not home during work days. The wall pipe inlet house was kept warm (average = 25°C) and was normally occupied. When ventilation was controlled by a de-humidistat set at 50% RH, the sparsely occupied code house fan was on 98% of the time while the occupied house fan was on only 12% of the time. See Appendix 5 for real time CO_2/RH tracking.

.2 In houses where unoccupied temperature setback is practised, occupancy may reduce relative humidity due to the increase in temperature upon occupation. Carbon dioxide may track occupancy with greater accuracy than relative humidity. See Figures 7, 8, and 9, for average temperature/RH relationships. See Appendix 5 for examples of the real time relationship between relative humidity and CO_2.

.3 Fan run time under de-humidistat control is influenced by the outdoor temperature. For example, using the 46 cfm rate from both the "B.C. Code" and "wall pipe inlet" houses in a theoretical calculation, makeup air at 15.5 deg.C and 80% RH brings over 19 ounces more water into the house each hour than makeup air at -1 deg.C and 90% RH.

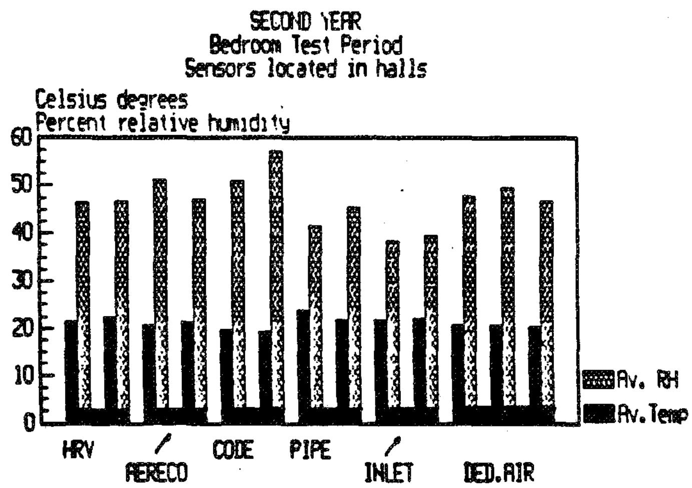
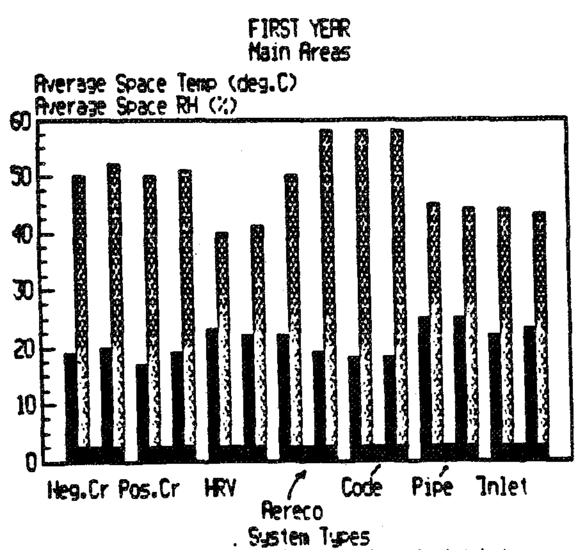


Figure 7.

8.



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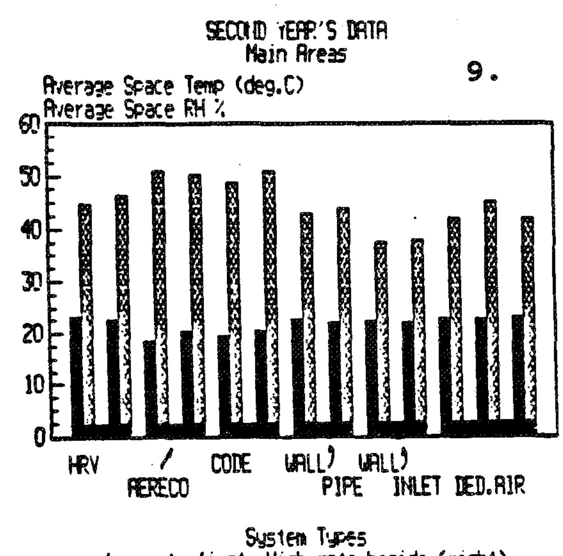


6.7 Energy Ramifications of Ventilation Strategies

Figure 10 shows the relative annual operating costs, per square foot of floor area, associated with the ventilation systems studied herein. Details of this calculation are presented in Appendix 6.

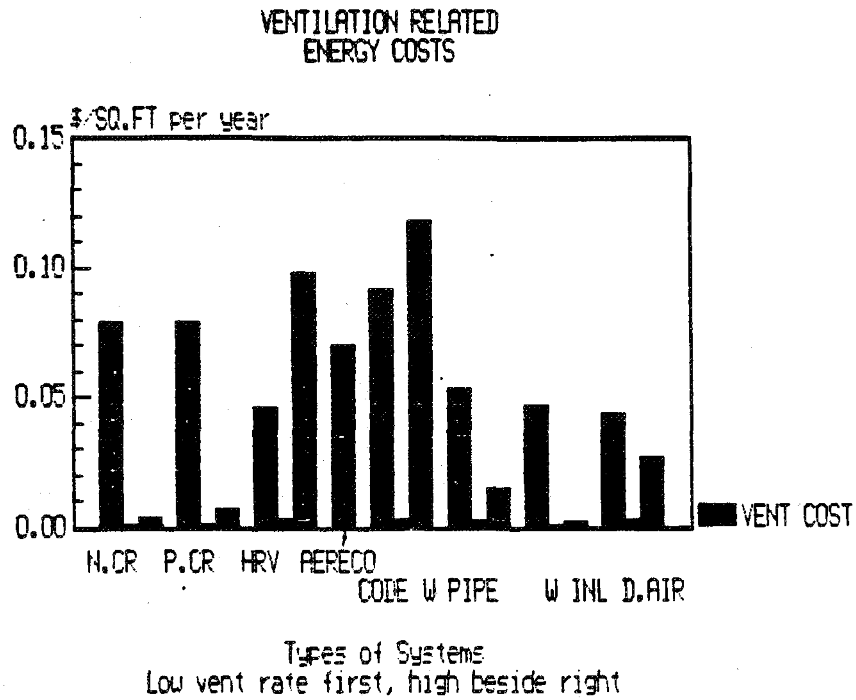


Figure 10.

.1 The results of the tracer gas tests (see Appendix 4) seem to indicate that the reported costs should be adjusted to reflect the added airchange brought about by uncontrolled envelope penetrations (crawlspace, wall pipe inlet, wall inlet systems, and, to a lesser degree, the Aereco system). The HRV and Code systems would likely not be as affected.

.2 De-humidistat control can be seen as an energy saver in most cases, however, this mode of control also provided the single highest cost (Code house). Space temperature is the determining factor. For example, if a house is at 21°C. and 49% RH as the people leave and set their thermostats back by 6 C.degrees, it could be at 15°C. and 72% RH when they arrive home. This assumes that the outdoor temperature is low enough and that the air is not changed in the house. Results from the monitoring of the "B.C. Code" house demonstrate that the effect is real.

.3 The size of the house is significant. The 2 houses containing HRVs demonstrate this. The "Dedicated Air" house is 3,000 ft^2 and shows a ventilation rate of 0.047 cfm/ft^2 at 0.35 ACH, while the "HRV" house, at 1,220 ft^2, shows a ventilation rate of 0.094 cfm/ft^2 at 0.31 ACH.

.4 The difference in annual energy cost between the "dedicated air" house minimum rate and the "B.C. Code" house minimum rate is $0.065/ft^2. This represents a $65.00 extra annual cost difference for a 1,000 ft^2 code house. Estimating that there are 20 million ft^2 (CMHC Victoria) of housing starts per year on Vancouver Island, this difference would represent 28 GWh/yr.

7.0 CONCLUSIONS

7.1 General

Based upon Health and Welfare Canada's Exposure Guidelines for Residential Indoor Air Quality, no contaminant threshold limit values were exceeded in any of the houses monitored. The action level for formaldehyde was seen in the "HRV" and "wall pipe" houses during the first year of monitoring. Commonly recognized "comfort levels" for carbon monoxide (5 ppm) were exceeded in the Aereco, "BC Code" and "wall pipe" houses. Seven of forty monitoring periods reported had average CO_2 levels which exceeded ASHRAE's suggested comfort level of 1,000 PPM. Health and Welfare Canada's relative humidity guideline (55%) was exceeded in 22 of the 40 test periods. The most highly ventilated home (HRV) came the closest to being a health concern with respect to CO_2. The main reason for this was its very high occupancy.

See Appendix 4 for a tabulation of results, and Appendix 5 for graphs of results.

7.2 Indoor Air Quality

.1 High occupancy, as seen in the "HRV" house, can cause poor air quality in a house ventilated at twice the minimum code requirement.

.2 System effectiveness can be seriously compromised by common installation practices and air distribution design. The "HRV" and Aereco houses demonstrate this for complex systems, and the "B.C. Code" house does so for simple systems.

.3 A reduction in "house drying" may account for lower RH levels in the second year of monitoring.

.4 The reduction in formaldehyde levels by the second year may be the result of diminished offgasing.

.5 Relative humidity levels exceeded 70% in only one of forty monitoring periods. This would seem to indicate that there is no concern with relative humidity, but the sample location was in hallways and bathrooms showed signs of mold growth. Based on the fact that mold was occurring, we conclude that the low ventilation rate (0.15 ACH), which the houses were operating at throughout the year, is not adequate. Furthermore, the proper location of a control de-humidistat would be important to the success of that control mode.

7.3 Carbon Monoxide

.1 No serious concerns arose throughout the course of this work, but the only house containing combustion appliances was very leaky, and it was monitored for only one year. In view of the above, it is difficult to draw meaningful conclusions about CO and its prevalence with certain ventilation systems.

.2 The location of plumbing and flue stacks, exhaust discharge, and parking (even open driveways), should be considered when choosing the location of makeup inlets.

7.4 Mechanical Ventilation.

.1 The "dedicated air" house "high" speed was based upon CSA F326 requirements, and more than doubled the minimum requirements of the B.C. Code.

.2 The volumes of air and methods of delivery specified by the current BC Code can easily result in under-ventilation of specific rooms in houses. CO_2 levels were high in almost all bedrooms. To have a relatively high confidence in the air quality throughout a house, makeup air should be delivered to, or exhaust air be taken from, each room in a house continuously. Furthermore, it is concluded that the quantity of air be specified at higher rates than presently required by the code. See Appendix 7 for schematic drawings of recommended systems.

.3 Although no carbon monoxide or combustion gas problems were encountered in this work, common sense dictates that negative pressures in excess of 5 Pa should be prevented, through ventilation design, in houses with spillage susceptible combustion appliances.

.4 Development of certification for installers and/or inspection/commissioning of systems would improve actual ventilation performance, particularly for the more sophisticated systems.

.5 Use of the dedicated air approach (closing air to the living areas during the night) resulted in a 50% increase in the amount of air delivered to the bedroom. Although this was not noticed by the occupants, probably due to the overall low air quantity, the principle is proven to be effective.

.6 De-humidistat fan control can result in poor air quality in warm houses. De-humidistat fan control can result in high energy consumption in cool houses.

.7 Houses which do not contain fully distributed ventilation systems (balanced per room) and where special attention has not been paid to the location of both exhaust and makeup, can contain poorly ventilated areas.

.8 Houses which rely on a single point of exhaust draw larger volumes of "contaminated" air to that point than are seen at any point in comparable houses having multiple exhaust points. See 6.4.7.

.9 Single point of admission of outdoor air with ducted distribution, is favoured, over one inlet per room, for its potential advantages in tempering, filtration, and controlled infiltration. If the exhaust discharge is located on the same orientation, with adequate clearance to prevent re-entry of exhaust air, the effects of wind can be lessened. The "wall pipe" technique, used in the study, can be used with the single point of entry to maximize tempering.

.10 Systems should be designed, or at least be approved, by trained, third party designers who will choose the appropriate system based on site (ground moisture, wind, solar exposure etc.), the application (multi-family/single family, high occupancy and so on), use of combustion appliances, and floor plan.

.11 The arrival of natural gas service to Vancouver Island is likely to result in a marked increase in the use of forced warm air systems.

.12 Improved pricing for developments in CO_2 control, occupancy detection, variable air volume, ventilation options for hydronic and electric baseboard systems, fan noise abatement, and combustion appliance interlocking will continue to increase the capabilities and complexity of residential ventilation.

.13 The range of installation costs for the systems outlined in Section 5 is $450 to $2,500. Whether the added cost of the sophisticated systems is justified is a widely debated topic. Similarly, there is debate over whether it is the individual's responsibility, or an agency's responsibility, to ensure healthy environments in private residences. This report is promoting practices which will help ensure good air quality in houses. The effects of energy efficiency on the province's electrical generating capacity (see section 6.7.4), and the effects of gas and oil furnaces on global warming should also be considered.

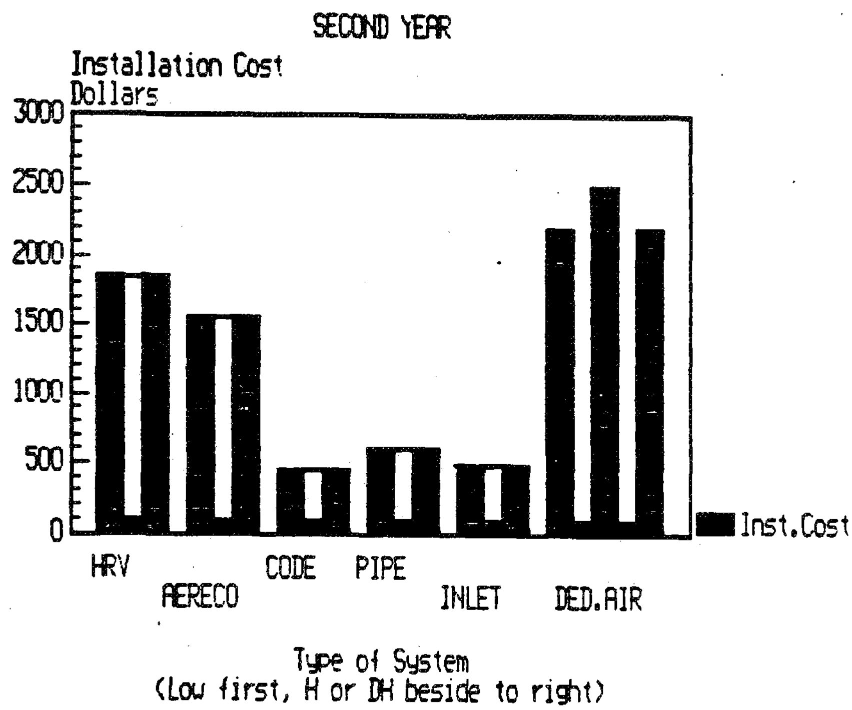


Figure 11.

7.5 Overall Ventilation

.1 The positive crawlspace system provided more controlled ventilation (less infiltration) than the negative crawlspace system.

.2 Mechanical ventilation, as measured at the fan, can be significantly less than effective ventilation in the space. Duct leakage, short circuiting from supply to exhaust grills, and undistributed systems can contribute to this.

.3 Undistributed systems having single or multiple wall penetrations can result in high infiltration rates which vary with wind and temperature conditions. Highly visible "straight through-wall" inlets are often plugged by occupants who are concerned with draughts or energy costs.

7.6 Energy Ramifications Associated with Ventilation Systems

.1 The simple calculation of fan and heat energy associated with mechanical ventilation does not tell the whole story. The impact that these systems have on natural ventilation should also be considered. The type, location and size of makeup air inlets, for example, is important.

.2 De-humidistat control results in considerable cost savings over continuous fan operation for dwellings maintained at occupied temperatures. Houses where lengthy setbacks occur, and/or where occupied temperatures are low, however, can be over-ventilated and have higher energy costs.

.3 Based on the calculated difference in annual energy cost between the "dedicated air" house minimum rate, and the "B.C. Code" house minimum rate, and an estimate of 20 million ft^2 of housing starts per year on Vancouver Island (CMHC Victoria), up to 28 GWh/yr extra consumption would result from the installation of all minimum "BC Code" systems, as opposed to all HRV, if all heating was electric. This extra consumption is enough to provide the complete energy needs of approximately 1,100 Quality Plus houses; each containing a family of 4.

APPENDIX 1

ANNUAL METEOROLOGICAL SUMMARY

for

VICTORIA, B.C.

CLIMATE

Victoria, B. C. enjoys a mild, maritime climate. Situated as it is on the southeastern tip of Vancouver Island, it is bounded by water on the south and east. Juan de Fuca Strait, some 18 miles wide, to the south of Victoria, lies between southern Vancouver Island and Washington State, U. S. A. Haro Strait, the Gulf Islands and the Strait of Georgia lie to the northeast between eastern Vancouver Island and the mainland.

The Olympic Mountain Range in Washington, some 25 to 30 miles to the south, rises sharply to 4000 to 5000 feet with Mount Angeles at a height of 6500 feet and Mount Olympus at 7913 feet. This range of mountains tends to shelter us from the major precipitation effects of many Pacific storms, since moisture laden air, from a southerly direction, may be dried considerably in passing northward across the mountain barrier, to produce a rain shadow across this region. Some increasing in shower activity results over the area when cool moist air from the northwest is forced to rise on the northern slopes of this mountain range.

A lower range of hills or mountains on southern Vancouver Island ranging from 1000 to 3000 feet give protection from moist westerly winds from the Pacific Ocean with the air being dried considerably as it drops much of its moisture on the windward or western slopes.

Normally this area is under the influence of a mild westerly circulation of air from the Pacific Ocean which in summer gives rise to pleasantly warm weather with abundant sunshine and some showery periods, while in the winter provides generally mild weather with considerable cloudiness and periods of rain. However periods of northerly winds in summer gives rise to clear hot weather, while these winds in winter keep the weather cool and mostly cloudy. Masses of very cold continental Arctic air, which from time to time pour southward into the interior of British Columbia and the Prairie Provinces, very infrequently reach Victoria, during the winter season. These outbreaks of cold, dry air are accompanied by a period of snow and strong northeasterly winds and followed by clearing and much colder weather. This is normally followed within a few days by a trend to milder weather with snow changing rapidly to rain as the temperatures rise with the arrival of the milder air from the Pacific Ocean. The highest temperature recorded during the summer has been 95.2 degrees on July 17, 1941 while the lowest winter temperature has been 3.8 degrees on December 29, 1968.

Extremely low humidities are not common but do occur with the warm dry northerly winds for short periods in the summer and the cool dry Arctic air which infrequently invades this area in the winter. Average relative humidity for Victoria in the summer months is 79 percent and in winter 86 percent.

The prevailing wind direction, as determined by the number of hours the wind blows from each direction, is from the North, during the months of October through to February, and from the Southwest during the period May to September, and from the West during March and April. Winds of gale force from the Southeast and Southwest, preceding and following Pacific storms onto the coast, are quite common in the winter months while a sea breeze from the Southwest is common during the summer afternoons.

CLIMATE (continued)

The cooling effect of this sea breeze is felt at Gonzales Observatory and along the southern shoreline of Victoria, and to a lesser degree northward away from the shoreline. Therefore temperatures experienced here with the afternoon sea breeze will be lower than those further inland from the water and the extent will depend upon the strength of the resultant penetration of the cooler air over the land areas.

With northerly winds, air reaches this observing point after passing over the land area to our north. Therefore temperatures as recorded here with northerly winds are representative of the Greater Victoria area. With clear skies and light winds at night, the cooling air collects in low lying more sheltered areas and temperatures are normally much lower in these areas than they are at the Observatory. The mixing and stirring of the air produced by the wind tends to minimize the temperature difference under stronger wind conditions. Therefore temperature observations taken in more sheltered areas of Victoria tend to be higher on the average during the summer months and lower during the winter months, than those recorded here. However over the year, the average temperature for all stations is near 50 degrees.

Victoria has the highest average number of hours of bright sunshine in British Columbia and one of the highest in Canada. Its average of just over 2200 hours of sunshine is exceeded by less than 100 hours by several stations on the southern prairies.

Patches of fog form from time to time, in low lying areas, during the Fall and Winter seasons but widespread heavy fog occurs very infrequently. During the Summer months banks of fog form in a northwesterly circulation of air along the West Coast of Vancouver Island, drift eastward through Juan de Fuca Strait and may invade the Victoria shoreline in the morning hours and retreat from the shoreline during the day.

ANNUAL METEOROLOGICAL SUMMARY
SOMMAIRE MÉTÉOROLOGIQUE ANNUEL

for/pour VICTORIA INTERNATIONAL AIRPORT YEAR ANNÉE 1987

METEOROLOGICAL DATA FOR THE YEAR / DONNÉES MÉTÉOROLOGIQUE POUR L'ANNÉE

NOTE: The following units are used throughout this summary —
Temperature: Degrees and tenths Celcius (°C)
Degree Day: Difference of Daily Mean Temperature from 18.0°C
Rain: Millimetres and tenths (mm)
Snow: Centimetres and tenths (cm)
Total Precipitation: Millimetres and tenths (mm)
Wind Speed: Kilometres per hour (km/h)
Wind Direction: Direction (true north) from which the wind is blowing.
Barometric Pressure: Kilopascals and hundredths (kPa)
Sunshine: Hours and tenths of bright sunshine.

AVIS: Unités Utilisées —
Température: Degrés et dixième Celsius (°C)
Degré Jour: Différence entre la température moyenne du jour et 18.0°C
Pluie: Millimetres et dixièmes (mm)
Neige: Centimetres et dixièmes (cm)
Précipitation Totale: Millimetres et dixièmes (mm)
Vitesse du vent: Kilomètres par heure (km/h)
Direction du vent: Direction (nord géographique) d'ou le vent souffle.
Pression Barométrique: Kilopascals et centièmes (kPa)
Insolation: Nombre d'heures et dixièmes d'insolation effective

MONTH MOIS	TEMPERATURE / TEMPÉRATURE										DEGREE DAYS DEGRÉS JOURS	
	MEAN / MOYENNE			NORMAL / NORMALE			EXTREME / EXTRÊME					
	MAXIMUM	MINIMUM	MONTHLY MENSUELLES	MAXIMUM	MINIMUM	MEAN MOYENNE	MAXIMUM MAXIMALE	DATE	MINIMUM MINIMALE	DATE	BELOW 18.0°C AU DESSOUS DE 18.0°C	NORMAL NORMALE
JAN/JAN	7.3	1.2	4.3	6.0	0.1	3.1	13.1	11	-3.5	8	425.0	463.5
FEB/FÉV	9.8	2.9	6.4	8.2	1.3	4.8	12.7	4	-2.7	28	325.9	374.5
MAR/MAR	11.2	2.7	7.0	9.6	1.7	5.7	17.4	31	-1.5	1	341.3	382.6
APR/AVR	14.3	4.7	9.5	12.9	3.9	8.4	22.8	27	-0.2	19	254.2	288.4
MAY/MAI	17.3	7.4	12.4	16.5	6.7	11.6	25.6	7	2.4	19	173.7	197.8
JUN/JUIN	20.5	9.2	14.9	19.2	9.4	14.3	28.3	29	4.7	2	97.2	113.9
JUL/JUIL	21.5	10.9	16.2	21.7	10.8	16.3	29.2	17	6.9	15	60.4	64.1
AUG/AOÛT	22.7	10.3	16.5	21.4	10.7	16.1	29.8	31	7.5	21	52.3	66.4
SEPT/SEP	20.9	8.6	14.8	19.0	8.7	13.9	30.3	1	5.2	27	101.1	124.9
OCT/OCT	17.0	4.8	10.9	14.1	5.6	9.9	27.6	1	0.9	26	219.1	251.8
NOV/NOV	10.7	4.0	7.4	9.4	2.5	6.0	14.6	1	-1.6	17	318.9	360.2
DEC/DÉC	6.5	0.3	3.4	7.1	1.3	4.2	10.9	6	-3.3	31	450.8	427.1
YEAR ANNÉE	15.0	5.6	10.3	13.8	5.2	9.5	30.3	Sep 1	-3.5	Jan 8	2819.9	3115.2

MONTH MOIS	PRECIPITATION / PRÉCIPITATIONS													
	MONTHLY / MENSUELLES			NORMAL / NORMALE			EXTREME / EXTRÊME							
							RAIN / PLUIE				SNOW / NEIGE			
	RAINFALL HAUTEUR DE PLUIE	SNOWFALL HAUTEUR DE NEIGE	TOTAL	RAIN PLUIE	SNOW NEIGE	TOTAL	6 HRS	DATE	24 HRS	DATE	6 HRS	DATE	24 HRS	DATE
JAN/JAN	127.9	TR	127.9	134.0	20.0	154.3	12.6	26	17.2	2	TR	26	TR	26
FEB/FÉV	60.0	5.2	65.2	91.1	8.1	99.2	20.0	1	21.6	1	4.0	28	5.2	28
MAR/MAR	77.9	TR	77.9	65.5	6.1	71.7	17.4	3	25.6	2	TR	1	TR	1
APR/AVR	51.2		51.2	38.9	0.3	39.3	7.8	30	18.8	30				
MAY/MAI	38.4		38.4	28.5		28.5	8.4	11	12.2	30				
JUN/JUIN	9.6		9.6	29.0		29.0	6.8	11	8.8	20				
JUL/JUIL	13.0		13.0	18.1		18.1	3.0	9	5.4	24				
AUG/AOÛT	11.4		11.4	26.7		26.7	5.6	13	7.4	13				
SEPT/SEP	1.8		1.8	39.6		39.6	0.6	14	1.2	14				
OCT/OCT	13.6		13.6	78.4		78.4	4.8	30	6.2	31				
NOV/NOV	71.0		71.0	128.4	2.3	130.8	17.0	21	19.6	21				
DEC/DÉC	174.7	1.0	175.7	144.4	13.1	157.3	34.6	9	70.4	9	1.0	18	1.0	18
YEAR ANNÉE	650.5	6.2	656.7	822.6	49.9	872.9	34.6	Dec 9	70.4	Dec 9	4.0	Feb 28	5.2	Feb 28

our VICTORIA INTERNATIONAL AIRPORT YEAR/ANNÉE: 1987

METEOROLOGICAL DATA FOR THE YEAR / DONNÉES MÉTÉOROLOGIQUE POUR L'ANNÉE

ONTH / MOIS	SUNSHINE / INSOLATION: Duration in hours / Durée (nombre d'heures)	Percentage of possible / Pourcentage du total possible	No. of days without sunshine / Nombre de jours sans soleil	Normal / Normale	WIND / VENT: Average speed / Vitesse moyenne	Prevailing direction / Direction dominante	Normal / Normale: Speed / Vitesse	Normal / Normale: Direction	Max for 1 min / Max pour 1 min: Direction and speed / Direction et vitesse	Max for 1 min: Date	Highest gust / Rafale maximum: Direction and speed / Direction et vitesse	Highest gust: Date
/JAN	60.6	22	9	63.8	9.2	SE	12.5	W	41 SE	2	67 SE	2
/FÉV	92.4	32	3	86.0	8.3	W	12.1	W	28 WNW	22	50 WSW	11
R/MAR	133.9	36	7	144.0	7.4	W	12.5	W	30 SE	16	44 SE	16
/AVR	179.4	44	4	180.3	9.3	W	12.1	W	30 WSW	16	43 SW	18
Y/MAI	288.6	61		255.9	9.3	W	11.1	W	33 WSW	31	52 SE	2
/JUIN	316.0	66		257.5	8.9	W	10.5	SE	28 WSW	14	44 WSW	21
/JUIL	292.7	60		329.0	8.7	W	9.5	SE	30 ESE	22	37 ESE	22
G/AOÛT	348.2	78	1	273.8	6.9	W	9.2	SE	28 SE	12	32 SE	12
T/SEP	269.5	71	1	194.7	6.5	W	9.1	W	28 WSW	2	44 WSW	2
T/OCT	214.0	64	1	144.3	5.9	W	10.1	W	20 SE*	2		
V/NOV	55.0	20	8	77.8	7.6	W	11.4	W	44 ESE	30	74 ESE	30
C/DÉC	73.4	28	10	51.6	10.2	W	12.7	W	46 SE	9	74 SE	1
EAR / NNÉE	2323.7	49	44	2058.7	8.2	W	11.1	W	46 SE	Dec 9	74 ESE	Nov 30*

* Indicates later occurrence of same speed/Indique des données postérieures de la même vitesse

BAROMETRIC PRESSURE*/PRESSION BAROMÉTRIQUE*

ONTH / MOIS	STATION LEVEL / NIVEAU DE LA STATION: Mean / Moyenne	Maximum / Maximale	Date	Minimum / Minimale	Date	Normal / Normale	SEA LEVEL / NIVEAU DE LA MER: Mean / Moyenne	Maximum / Maximale	Date	Minimum / Minimale	Date	Normal / Normale
N/JAN	101.56	103.51	15	98.99	3	101.63	101.80	103.76	15	99.22	3	101.88
B/FÉV	101.50	103.14	19	99.20	1	101.64	101.73	103.38	19	99.43	1	101.89
R/MAR	101.24	103.12	28	99.47	3	101.56	101.48	103.36	28	99.71	3	101.81
R/AVR	101.53	102.98	19	100.05	30	101.65	101.77	103.22	19	100.28	30	101.90
Y/MAI	101.41	102.56	5	99.85	30	101.67	101.64	102.80	5	100.08	30	101.92
/JUIN	101.54	102.93	2	100.48	29	101.60	101.77	103.17	2	100.71	29	101.85
/JUIL	101.26	102.24	31	100.29	17	101.74	101.49	102.47	31	100.52	17	101.95
G/AOÛT	101.58	102.45	17	100.48	13	101.62	101.81	102.69	17	100.71	13	101.87
T/SEP	101.63	102.61	27	100.71	14	101.61	101.87	102.85	27	100.94	14	101.86
T/OCT	101.84	102.97	26	100.73	31	101.61	102.07	103.21	26	100.96	31	101.86
V/NOV	101.53	103.16	25	99.21	30	101.59	101.77	103.41	25	99.44	30	101.84
C/DÉC	101.44	103.68	12	98.57	9	101.54	101.67	103.93	12	98.80	9	101.79
YEAR / ANNÉE	101.51	103.68	Dec 12	98.57	Dec 9	101.62	101.74	103.93	Dec 12	98.80	Dec 9	101.87

Kilopascal = 0.29529 inches of mercury / 3.386 kilopascals = 1 inch of mercury
= 0.29529 pouces de mercure / 3.386 kilopascals = 1 pouce de mercure

[illegible] METEOROLOGICAL SUMMARY
[illegible] METEOROLOGIQUE ANNUEL

[illegible] VICTORIA INTERNATIONAL AIRPORT — YEAR/ANNÉE: 1987

MONTHLY AND ANNUAL EXTREMES OF RECORD/EXTRÊMES MENSUELS ET ANNUELS AUX REGISTRES

MONTH MOIS	TEMPERATURE / TEMPÉRATURE								PRECIPITATION / PRÉCIPITATIONS					
	ABSOLUTE MAXIMUM ABSOLU	YEAR ANNÉE	ABSOLUTE MINIMUM ABSOLU	YEAR ANNÉE	HIGHEST MONTHLY MEAN MOYENNE MENSUELLE MAXIMALE	YEAR ANNÉE	LOWEST MONTHLY MEAN MOYENNE MENSUELLE MINIMALE	YEAR ANNÉE	GREATEST MONTHLY PRECIPITATION MENSUELLE MAXIMALE	YEAR ANNÉE	LEAST MONTHLY PRECIPITATION MENSUELLE MINIMALE	YEAR ANNÉE	GREATEST MONTHLY SNOWFALL NEIGE MENSUELLE MAXIMALE	YEAR ANNÉE
JAN/JAN	15.4	1984	-15.6	1950	6.3	1983	-4.4	1950	358.9	1953	19.0	1985	81.5	1950
FEB/FÉV	18.3	1963	-15.0	1950	7.3	1963	2.1	1956*	176.0	1961	38.6	1966	44.5	1949
MAR/MAR	20.0	1942*	-8.9	1951	9.0	1941	3.7	1955	144.5	1972	17.0	1965	31.2	1951
APR/AVR	24.4	1971	-3.9	1956	11.3	1941	6.4	1972	104.7	1970	2.0	1956	7.1	1955
MAY/MAI	31.5	1983	-1.1	1954	14.2	1958	9.8	1974	102.1	1948	8.9	1972	TR	1955
JUN/JUIN	33.3	1942	2.2	1976	16.9	1958	12.4	1971	82.8	1956	2.5	1951		
JUL/JUIL	36.1	1941	4.1	1979	19.1	1958	14.4	1955	49.8	1966	Nil	1958		
AUG/AOÛT	34.4	1960	4.4	1973	18.0	1942	14.5	1973	96.5	1975	Nil	1986		
SEPT/SEP	31.1	1955	-1.1	1972	15.9	1957	11.9	1972	86.4	1959	1.8	1987	TR	1972
OCT/OCT	27.6	1987	-4.4	1956	12.1	1944	8.1	1949	207.3	1975	13.6	1987	TR	1984
NOV/NOV	18.5	1975	-13.3	1955	8.9	1949	0.7	1985	267.0	1955	29.0	1943	45.6	1985
DEC/DÉC	16.1	1940*	-14.4	1964*	6.3	1950	1.1	1961	294.9	1972	22.9	1985	74.7	1968
YEAR ANNÉE	36.1	Jul 1941	-15.6	Jan 1950	19.1	Jul 1958	-4.4	Jan 1950	358.9	Jan 1953	Nil	Jul 1958*	81.5	Jan 1950

PERIOD OF RECORD/PÉRIODE DE REGISTRE: 1941 - 1987

* Indicates first of more than one occurrence/Indique le premier de plusieurs

for/pour VICTORIA INTERNATIONAL AIRPORT — YEAR/ANNÉE: 1987

MONTHLY AND ANNUAL DEGREE-DAYS/DEGRÉS-JOURS MENSUELS ET ANNUELS

MONTH MOIS	DEGREE-DAYS ABOVE/DEGRÉS-JOURS AU DESSUS DE					DEGREE-DAYS BELOW/DEGRÉS-JOURS AU DESSOUS DE				
	5 °C	18 °C	°C	°C	°C	18 °C	°C	°C	°C	°C
JAN/JAN	24.9					425.0				
FEB/FÉV	47.6					325.9				
MAR/MAR	73.5					341.3				
APR/AVR	137.8					254.2				
MAY/MAI	229.3					173.7				
JUN/JUIN	294.4	2.6				97.2				
JUL/JUIL	347.7	5.1				60.4				
AUG/AOÛT	357.5	6.8				52.3				
SEP/SEP	293.9	5.1				101.1				
OCT/OCT	186.5					219.1				
NOV/NOV	76.2					318.9				
DEC/DÉC	22.2					450.8				
YEAR ANNÉE	2091.5	19.6				2819.9				

VICTORIA, GONZALES HEIGHTS, B.C. YEAR/ANNÉE 1997

METEOROLOGICAL DATA FOR THE YEAR / DONNÉES MÉTÉOROLOGIQUE POUR L'ANNÉE

TE: The following units are used throughout this summary —	AVIS: Unités Utilisées —
Temperature: Degrees and tenths Celcius (°C)	Température: Degrés et dixième Celsius (°C)
Degree Day: Difference of Daily Mean Temperature from 18.0°C	Degré Jour: Différence entre la température moyenne du jour et 18.0°C
Rain: Millimetres and tenths (mm)	Pluie: Millimetres et dixièmes (mm)
Snow: Centimetres and tenths (cm)	Neige: Centimetres et dixièmes (cm)
Total Precipitation: Millimetres and tenths (mm)	Précipitation Totale: Millimetres et dixièmes (mm)
Wind Speed: Kilometres per hour (km/h)	Vitesse du vent: Kilomètres par heure (km/h)
Wind Direction: Direction (true north) from which the wind is blowing.	Direction du vent: Direction (nord géographique) d'ou le vent souffle.
Barometric Pressure: Kilopascals and hundredths (kPa)	Pression Barométrique: Kilopascals et centièmes (kPa)
Sunshine: Hours and tenths of bright sunshine.	Insolation: Nombre d'heures et dixièmes d'insolation effective

MONTH MOIS	TEMPERATURE / TEMPÉRATURE										DEGREE DAYS DEGRÉS JOURS	
	MEAN / MOYENNE			NORMAL / NORMALE			EXTREME / EXTRÊME					
	MAXIMUM	MINIMUM	MONTHLY MENSUELLES	MAXIMUM	MINIMUM	MEAN MOYENNE	MAXIMUM MAXIMALE	DATE	MINIMUM MINIMALE	DATE	BELOW 18.0°C AU DESSOUS DE 18.0°C	NORMAL NORMALE
JAN	7.5	3.6	5.6	6.1	2.1	4.1	14.3	11	-1.3	15	394.7	430.0
FEB/FÉV	10.0	5.5	7.8	8.2	3.4	5.8	13.2	10	2.9	28	296.9	345.1
MAR	11.7	5.5	8.6	9.6	3.7	6.7	17.5	31	0.6	1	299.9	350.7
APR/AVR	13.7	7.0	10.4	12.6	5.6	9.1	20.3	26	3.1	17	229.3	266.3
MAY/MAI	16.8	8.8	12.8	15.7	7.9	11.9	24.6	8	6.2	16	161.0	191.8
JUN/JUIN	19.1	10.1	14.6	17.7	9.8	13.8	28.2	25	6.4	2	103.8	129.1
JUL/JUIL	19.5	11.3	15.4	19.7	11.1	15.4	25.6	17	8.8	15	81.7	87.1
AUG/AOÛT	20.7	11.6	16.2	19.4	11.3	15.3	29.5	31	9.3	21	69.1	85.9
SEPT/SEP	19.5	10.9	15.2	18.0	10.4	14.2	29.1	1	7.9	27	87.6	117.0
OCT	16.4	9.8	12.6	13.7	7.9	10.8	24.6	1	5.3	24	169.3	223.1
NOV	11.1	6.8	9.0	9.3	5.0	7.2	14.0	9	2.2	17	270.6	325.2
DEC/DÉC	7.2	3.0	5.1	7.2	3.3	5.3	10.7	8	-0.4	24	398.6	395.4
YEAR ANNÉE	14.4	7.7	11.1	13.1	6.8	10.0	29.5	Aug 31	-1.3	Jan 15	2531.5	2946.7

MONTH MOIS	PRECIPITATION / PRÉCIPITATIONS													
	MONTHLY / MENSUELLES			NORMAL / NORMALE			EXTREME / EXTRÊME							
							RAIN / PLUIE				SNOW / NEIGE			
	RAINFALL HAUTEUR DE PLUIE	SNOWFALL HAUTEUR DE NEIGE	TOTAL	RAIN PLUIE	SNOW NEIGE	TOTAL	6 HRS	DATE	24 HRS	DATE	6 HRS	DATE	24 HRS	DATE
JAN	104.6	0.8	105.4	98.0	13.7	110.7			32.0	31			0.6	31
FEB/FÉV	20.7	0.0	20.7	69.4	4.1	73.6			9.8	28			0.0	
MAR	31.4	0.0	31.4	41.8	4.9	46.9			10.0	2			0.0	
APR/AVR	34.2	0.0	34.2	30.2	0.3	30.4			5.8	30			0.0	
MAY/MAI	21.0	0.0	21.0	19.3	0.0	19.3			8.0	11			0.0	
JUN/JUIN	1.8	0.0	1.8	20.1	0.0	20.1			0.9	11			0.0	
JUL/JUIL	11.6	0.0	11.6	13.4	0.0	13.4			5.0	4			0.0	
AUG/AOÛT	13.8	0.0	13.8	21.0	0.0	21.0			13.0	12			0.0	
SEPT/SEP	4.2	0.0	4.2	33.5	0.0	33.5			2.6	14			0.0	
OCT	3.8	0.0	3.8	63.4	0.0	63.4			3.4	29			0.0	
NOV	54.6	0.0	54.6	94.1	1.3	95.7			12.6	30			0.0	
DEC/DÉC	110.5	0.0	110.5	111.4	7.7	119.2			29.2	9			0.0	
YEAR ANNÉE	412.2	0.8	413.0	615.6	32.0	647.2			32.0	Jan 31			0.6	Jan 31

-hour Extreme Rain/Snow refers to 1 PRECIPITATION DAY (18Z-18Z) for/pour VICTORIA, GONZALES HEIGHTS, B.C. · YEAR/ANNÉE: 1987

METEOROLOGICAL DATA FOR THE YEAR / DONNÉES MÉTÉOROLOGIQUE POUR L'ANNÉE

MONTH MOIS	SUNSHINE / INSOLATION				WIND / VENT							
	DURATION IN HOURS DURÉE (NOMBRE D'HEURES)	PERCENTAGE OF POSSIBLE POURCENTAGE DU TOTAL POSSIBLE	NO. OF DAYS WITHOUT SUNSHINE NOMBRE DE JOURS SANS SOLEIL	NORMAL NORMALE	AVERAGE SPEED VITESSE MOYENNE	PREVAILING DIRECTION DIRECTION DOMINANTE	NORMAL NORMALE: SPEED VITESSE	NORMAL NORMALE: DIRECTION	MAX FOR 1 MIN MAX POUR 1 MIN: DIRECTION AND SPEED DIRECTION ET VITESSE	MAX FOR 1 MIN: DATE	HIGHEST GUST RAFALE MAXIMUM: DIRECTION AND SPEED DIRECTION ET VITESSE	HIGHEST GUST: DATE
JAN/JAN	74.8	27	4	68.1	16.9	N	19.2	N	E 79	2	ESE 118	2
FEB/FÉV	96.5	34	3	96.0	16.9	N	18.5	N	W 76	1	W 103	1
MAR/MAR	124.9	34	5	151.0	15.6	N	18.3	WSW	SW 60	25	SW 90	25
APR/AVR	197.7	43	3	201.9	16.9	SW	19.2	WSW	S 60	9	SW 98	7
MAY/MAI	298.6	63	0	276.9	17.0	SW	19.6	WSW	SE 52	2	ESE 81	2
JUN/JUIN	351.8	73	0	274.8	16.9	SW	18.6	WSW	SW 47	8	WSW 69	15
JUL/JUIL	297.7	59	0	341.8	M	M	17.4	WSW	M M	M	WSW 76	15
AUG/AOÛT	360.5	91	1	298.4	14.5	SW	16.4	WSW	SW 55	4	WSW 72	4
SEPT/SEP	M	M	M	205.7	13.8	SW	14.0	WSW	W 47	1	WSW 71	2
OCT/OCT	220.9	66	1	144.9	11.7	N	15.9	N	S 42	2	WSW 48	23
NOV/NOV	62.1	22	6	93.0	15.6	N	18.2	N	E 77	30	ESE 116	30
DEC/DÉC	70.3	27	10	58.7	19.3	N	19.7	N	E 74	8	SSW 114	9
YEAR ANNÉE	M	M	M	2191.0	15.9	SW	17.7	WSW	E 79	Jan 2	ESE 118	Jan 2

BAROMETRIC PRESSURE*/PRESSION BAROMÉTRIQUE*

MONTH MOIS	STATION LEVEL / NIVEAU DE LA STATION						SEA LEVEL / NIVEAU DE LA MER					
	MEAN MOYENNE	MAXIMUM MAXIMALE	DATE	MINIMUM MINIMALE	DATE	NORMAL NORMALE	MEAN MOYENNE	MAXIMUM MAXIMALE	DATE	MINIMUM MINIMALE	DATE	NORMAL NORMALE
JAN/JAN												
FEB/FÉV												
MAR/MAR												
APR/AVR												
MAY/MAI												
JUN/JUIN						NOT AVAILABLE						
JUL/JUIL												
AUG/AOÛT												
SEPT/SEP												
OCT/OCT												
NOV/NOV												
DEC/DÉC												
YEAR ANNÉE												

*1 Kilopascal = 0.29529 inches of mercury / 3.386 kilopascals = 1 inch of mercury
= 0.29529 pouces de mercure / 3.386 kilopascals = 1 pouce de mercure

APPENDIX 2.

RESIDENTIAL CODES AND STANDARDS

• **SUBSECTION 9.33.3. MECHANICAL VENTILATION**
(See Appendix A.)

Mechanical ventilation requirements

9.33.3.1. Except as required in Article 9.33.3.2., *dwelling units* shall have a mechanical ventilation system capable of providing, during the heating season, at least 0.5 air change per hour or according to Table 9.33.3.A.

9.33.3.2. Mechanical ventilation systems in *dwelling units* designed in accordance to Part 6 to distribute ventilation air to or from all habitable rooms, but excluding such rooms as storage, foyer, laundry or mechanical rooms, shall be capable of providing, during the heating season, not less than 0.3 air change per hour or according to Table 9.33.3.A.

9.33.3.3. The rate of air change in Articles 9.33.3.1. and 9.33.3.2., and Table 9.33.3.A shall be based on the total interior volume of all *storeys* including the *basement* and heated crawl spaces, but excluding any attached or built-in garage.

Table 9.33.3.A.
Forming Part of Articles 9.33.3.1. and 9.33.3.2.

MINIMUM REQUIRED VENTILATION RATE			
Max. Total Interior Volume(1), m^3	Max. Total Floor Area(1) Based On Standard 2.44 m Ceiling Height, m^2	Minimum Ventilation Rate	
		0.5 Air Change per Hour, L/s	0.3 Air Change per Hour, L/s
122	50	17	10
146	60	20	12
171	70	24	14
195	80	27	16
220	90	31	18
244	100	34	20
366	150	51	31
488	200	68	41
610	250	85	51
732	300	102	61
975	400	137	82
1219	500	171	102
1463	600	205	123
Column 1	2	3	4

Notes to Table 9.33.3.A.:

(1) For rooms or spaces to be included or excluded see Article 9.33.3.3.

Rooms or spaces without natural ventilation

9.33.3.4. Where a habitable room or space in a *dwelling unit* is not provided with natural ventilation described in Article 9.33.1.5., mechanical ventilation shall be provided to that room or space that is capable of providing 0.5 air change per hour if the room or space is mechanically cooled in summer, and 1.0 air change per hour if it is not.
(See Appendix A.)

Automatic or continuous operation

9.33.3.5. A portion of the ventilation rate required by Articles 9.33.3.1. and 9.33.3.2. shall be controlled automatically by a centrally located dehumidistat, or be provided by a continuously operating fan during the heating season. This portion of ventilation rate shall conform to Table 9.33.3.B. (See Appendix A.)

Table 9.33.3.B.
Forming Part of 9.33.3.5.

MINIMUM REQUIRED VENTILATION RATE CONTROLLED AUTOMATICALLY OR PROVIDED CONTINUOUSLY			
Max. Total Interior Volume(1), m^3	Max. Total Floor Area(1) Based On Standard 2.44 m Ceiling Height, m^2	Minimum Ventilation Rate, Controlled Automatically, L/s	Minimum Ventilation Rate, Provided Continuously, L/s
244	100	20	10
366	150	30	15
488	200	40	20
732	300	40	30
975 and over	400 and over	40	40
Column 1	2	3	4

Notes to Table 9.33.3.A.:

(1) For rooms or spaces to be included or excluded see Article 9.33.3.3.

9.33.3.6. Except as provided for in Subsection 9.33.4. or as otherwise stated in this Subsection, mechanical ventilation shall conform to the requirements of Part 6.

Make-up Air **9.33.3.7.** Except as provided in Articles 9.33.3.8. and 9.33.3.14., mechanical ventilation systems for *dwelling units* shall include provision for introduction of fresh make-up air from the exterior for the ventilation rate controlled automatically or provided continuously as described in Article 9.33.3.5.

Make-up Air not required **9.33.3.8.** Make-up air as described in Articles 9.33.3.7. and 9.33.3.13. is not required, if the *dwelling unit* does not contain a naturally-aspirating fuel-fired heating *appliance*, or if all fuel-fired *appliances* are isolated from the *dwelling unit* atmosphere. *Acceptable appliances* include induced draft or sealed *furnaces*, gas fireplaces and hot water tanks, with combustion air directly from outside and with sealed *flues;* or fireplaces and *space heaters* that are equipped with tight-fitting, gasketed doors with all air supply requirements directly from the outside into the firebox.

Make-up Air tempered **9.33.3.9.** Make-up air shall be tempered as described in Articles 9.33.3.10. to 9.33.3.12.

9.33.3.10. For locations with winter design temperature not less than -10°C make-up air may be tempered by being supplied by ducting into secondary areas such as utility or storage rooms, by specially designed individual room or space through-wall diffusers, by methods described in Article 9.33.3.11., or by other *acceptable* methods.

9.33.3.11. For locations with winter design temperature less than -10° C make-up air may be tempered by being supplied through a forced air heating system as described in Article 9.33.3.12., by heating/fan unit, by heat recovery ventilator, or by other *acceptable* methods.

Make-up Air tempered by forced-air heating systems **9.33.3.12.** Make-up air tempered through forced-air heating systems shall be provided by a duct connected to the return-air *plenum*. The make-up air duct shall be at least 100 mm diam or an equivalent combined duct with the furnace air supply. The make up air duct shall be provided with a motorized damper that is interlocked with the exhaust fan controlled by the dehumidistat so that the exhaust fan only operates when the damper is in the open position. The dehumidistat shall also be interlocked with the furnace air circulating fan so that the furnace fan will operate when the exhaust fan is on and the damper is open.
(See Example (c) in A-9.33.3.)

B.C. BUILDING CODE 1985
FIRST REVISIONS
SEPTEMBER 1988

Make-up air for other exhaust appliances **9.33.3.13.** Except as described in Article 9.33.3.8., addition separate make-up air for the entire capacity shall be provided f other exhaust *appliances* installed in the *dwelling unit* with a rate exhaust capacity exceeding 0.5 air change per hour, or according Table 9.33.3.A. Non-forced make-up air shall conform to Tab 9.33.4.4. for the rates indicated, otherwise the make-up air shall provided by a fan-forced unit of equivalent capacity interlocked wi the exhaust appliance.

Combination forced air/ ventilation sytem **9.33.3.14.** A naturally-aspirating forced air heating syste serving a maximum total heated floor area of 460 m^2 is *acceptab* as providing the ventilation requirements, if the system is capat of providing at least 0.3 air changes per hour during its heati operation or has an air supply according to Table 9.33.3.C. Tl system shall have a ventilation rate controlled automatically o provided continuously by the furnace air circulating fan as requir by Article 9.33.3.5., and have the required air supply according Table 9.33.3.C., provided directly to the return-air *plenum*.
(See Example (b) in A-9.33.3.)

Table 9.33.3.C.
Forming Part of 9.33.3.14.

MINIMUM AIR SUPPLY DUCT(1) DIAMETER FOR A COMBINATION FORCED AIR/VENTILATION SYSTEM

Max. Total Interior Volume(2), m^3	Max.Total Floor Area(2) Based On Standard 2.44 m Ceiling Height, m^2	Minimum Air Supply Duct(1) Diameter, mm
536	220	100
805	330	125
1122	460	150
Column 1	2	3

Notes to Table 9.33.3.C.:

(1) The air supply duct has been sized for one duct to provide both for the air supply as required by the furnace installation code and for the ventilation air required by this Subsection.

(2) For rooms or spaces to be included or excluded see Article 9.33.3.3.

9.33.3.15. Special purpose air exhausting equipment such as central vacuum cleaning systems, downdraft cook tops and clothes dryers shall not be included in calculating the capacity of the ventilation system.

9.33.3.16. Systems designed to provide combustion and/or dilution air for fuel-burning *appliances* shall not be used to supply make-up air for the ventilation systems unless their capacity is sufficient to serve both functions simultaneously. An *acceptable* combination system includes a forced air heating system as described in Article 9.33.3.14.

ound rating **9.33.3.17.** Wall and ceiling fans required by Article 9.33.3.5. to be controlled automatically or operate continuously, shall be rated by the manufacturer not to exceed a sound level of 60 dBA or 2.5 Sones.

xhaust ıcts **9.33.3.18.** *Exhaust ducts* shall discharge directly to the outdoors. Where the *exhaust duct* passes through or is adjacent to unheated space, the duct shall be insulated to prevent moisture condensation in the duct.

ccess to entilation ıuipment **9.33.3.19.** Ventilation equipment shall be accessible for inspection, maintenance, repair and cleaning. Except where the kitchen exhaust grille is located at least 1.2 m horizontally from the range, kitchen *exhaust ducts* shall be designed and installed so that the entire duct can be cleaned where the duct is not equipped with a filter at the intake end.

ir intake ıield **9.33.3.20.** Outdoor air intake and exhaust outlets shall be shielded from weather and insects. Shielding from insects for ventilating equipment may be by an accessible filter at the equipment and by a 6 mm mesh screen at the intake or exhaust hood. Screening if used shall be of rust-proof material.

uct equirements **9.33.3.21.** Ventilating ducts shall conform to the requirements of Part 6 for *supply ducts*, except *exhaust ducts* that serve only a bathroom or water-closet room may be of *combustible* material provided the duct is reasonably air tight and constructed of a material impervious to water.

oors ndercut **9.33.3.22.** Interior doors for dwelling units shall be undercut a minimum of 12 mm or the rooms shall be provided with a grille of an equivalent area.

B.C. BUILDING CODE 1985
FIRST REVISIONS
SEPTEMBER 1988

SUBSECTION 9.33.4. BASIC MECHANICAL VENTILATION SYSTEM

(See Appendix A and Example (a) in A-9.33.4.)

General **9.33.4.1.** A basic mechanical ventilation system shall comply with the requirements in Article 9.33.3.1. and shall consist of one or more exhaust fans, without an air circulating ductwork system. The exhaust fans shall be located in some or all of the kitchens and bathrooms. The ventilation system shall conform to the appropriate requirements of Subsection 9.33.3., except the system need not conform to Part 6.

Exhaust fan **9.33.4.2.** The exhaust fans required in Article 9.33.4.1. shall be rated for sound as required in Article 9.33.3.17. and controlled automatically by a dehumidistat as required in Article 9.33.3.5.

System capacity **9.33.4.3.** The mechanical ventilation capacity of the exhaust fans in Article 9.33.4.1. shall be assumed as the total of the individual fans, rated by the manufacturer at a differential pressure of at least 50 Pa. The exhaust duct size shall conform to Table 9.33.4.A.

Table 9.33.4.A.
Forming Part of Article 9.33.4.3.

EXHAUST DUCT(1) SIZE FOR A BASIC VENTILATION SYSTEM IN SUBSECTION 9.33.4.

Maximum Exhaust Fan Ventilation Rate, L/s	Min. Exhaust Duct(1) Dia.	
	Smooth Duct	Flexible Duct
10	75	100
25	100	125
45	125	150
70	150	175
Column 1	2	3

Notes to Table 9.33.4.A.:

(1) The exhaust ducts shall not exceed 15 m in length or have more than two 90° elbows, otherwise the duct shall be increased to the next diameter size.

Make-up air **9.33.4.4.** Make-up air shall be provided for the ventilation rate controlled automatically or provided continuously as described in Article 9.33.3.5. and shall conform with Articles 9.33.3.7. to 9.33.3.11. The non-forced air opening size for make-up air for a basic ventilation system as provided for in this Subsection shall conform to Table 9.33.4.B. Forced make-up air equipment shall be rated by the manufacturer to provide for the required air flow rate.

Table 9.33.4.B.
Forming Part of Article 9.33.4.B.

MAKE-UP AIR OPENING SIZE FOR A BASIC VENTILATION SYSTEM IN SUBSECTION 9.33.4.

Maximum Ventilation Rate Controlled Automatically or Provided Continuously, L/s	Mimimum Make-up Air Duct	
	Vent Area, cm^2	Diam, mm
8	47	80
12	66	90
15	85	100
17	95	110
20	114	120
25	142	130
30	170	150
35	199	160
40	227	170
45	255	180
50	284	190
55	312	200
60	340	210
Column 1	2	3

B.C. BUILDING CODE 1985
FIRST REVISIONS
SEPTEMBER 1988

	Page	Reference	Revision
*	400	9.34.1.7.	In the fourth line change: "0.018 m^2" to "100 mm diam or equivalent area".
*	403	9.35.1.5. & 9.35.1.6.	Add new Articles: **9.35.1.5.** Except as required in Article 9.35.1.6., electrical wiring and cables installed in *buildings* permitted to be of *combustible construction* shall conform to Sentence 3.1.4.1.(3). **9.35.1.6.** Where a concealed space in a floor or ceiling assembly is used as a *plenum*, electrical wiring and cables within the *plenum* shall conform to Clause 3.5.4.3.(1)(a).
|	457	Appendix A	Add new note: **A-3.1.4.1.(3)(d)(i)** The term raceway is defined in CSA C22.1, "Canadian Electrical Code, Part 1" and includes both rigid and flexible conduit.
*	492	Appendix A	Add new Note: **A-9.6.6.4. Hinge and Strikeplate Fastening.** When hinges and strikeplates are installed they must fasten into solid wood. Screws should be sufficiently long to either pass through a thin door jamb, cross a shimmed back space and penetrate at least 25 mm into structural framing or, in the case of a door with a sidelight where the mullion may be the structural component, penetrate at least 25 mm into the mullion.

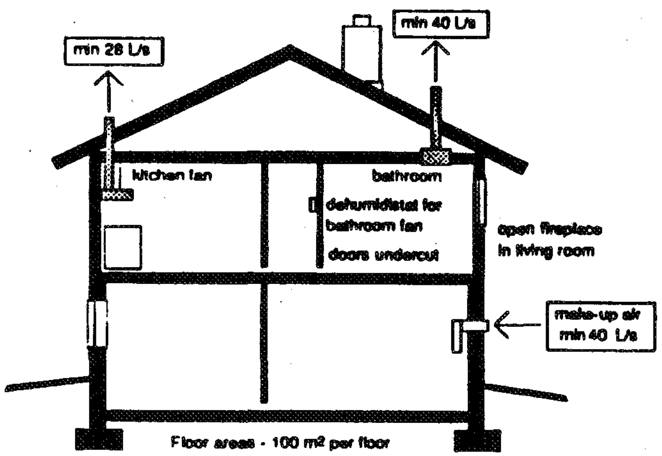
Page	Reference	Revision
492	Appendix A	**A-9.7.2.1. Windows.** The CSA Standard CAN3-A440, "Windows", includes a window classification system that rates the assembly according to air leakage, water leakage and wind load resistance. the ratings, shown below, are marked on the window and indicate the level of performance that can be expected. Units can then be selected which are most appropriate for the design conditions. **Air Leakage** A1-intended for use primarily in low-rise residential (i.e. building of 3 storeys or less and having an area not exceeding 600 m^2), industrial, and light commercial use. A2-intended for use primarily in medium-to high-rise residential, institutional, and commercial use. A3-intended for use in high-performance institutional and commercial applications. **Water Leakage** B1-moderate climatic conditions B2-severe climatic conditions B3-extreme climatic conditions **Wind Resistance** C1-lowest wind load resistance C2-medium wind load resistance C3-highest wind load resistance Article 9.7.2.1. has specified the lowest grades since the NBC is a collection of minimum requirements only. Designers or builders may wish to consider windows with higher ratings depending on the height of buildings, climatic conditions and occupancy classification.

B.C. BUILDING CODE 1985
FIRST REVISIONS
SEPTEMBER 1988

Page	Reference	Revision
• 501	Appendix A	Delete all existing Appendix Notes Subsection 9.33.3. and substitute t following: **A-9.33.3. & A-9.33.4. Mechanic Ventilation.** Subsection 9.33.3. conta the general requirements for mechani ventilation systems for dwelling units. also references Part 6 for the design of t ventilation systems, except for the "Ba Mechanical Ventilation System" described Subsection 9.33.4. Part 6 in turn requi good engineering practice, such as found ASHRAE handbooks and HRAI Digest for t design of ventilation systems. Subsection 9.33.4. "Basic Mechanic Ventilation System", contains the speci requirements for the installation a verification of a simple ventilation syste utilizing exhaust fans and make-up air required. The following examples illustrate differ ventilation systems and how the requireme can be satisfied depending on the heati system used. The house used in the examples has two storeys with 100 m^2 floor and contains an open fireplace.

Example (a): shows the Basic Mechanical Ventilation System as described in Subsection 9.33.4., this can be used with any heating system. For this example the following would apply:

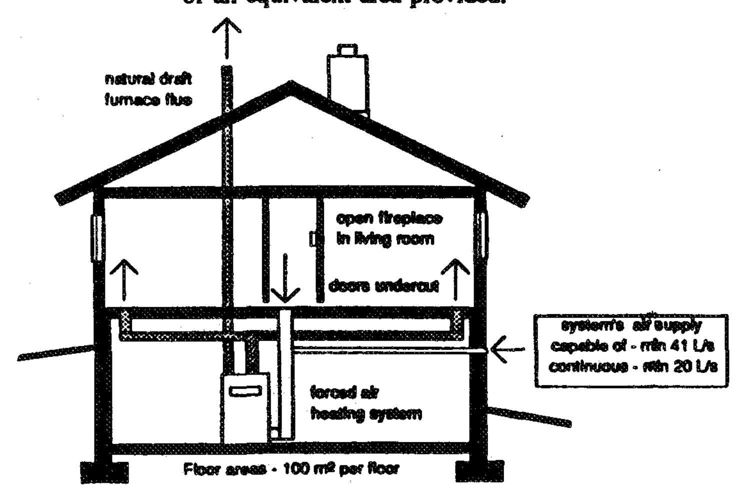
1. 9.33.4.1. - 0.5 air changes per hour or from Table 9.33.3.A. for 200 m^2 a minimum ventilation rate of 68 L/s is required, this is provided by kitchen and bathroom exhaust fans;
2. 9.33.4.2. - the bathroom fan to be rated for a maximum sound rating of 60 dBA (2.5 sones), be controlled by a dehumidistat and from Table 9.33.3.B. a minimum ventilation rate of 40 L/s is required;
3. 9.33.4.3. - fans to be rated at a minimum of 50 Pa, exhaust duct size according to Table 9.33.4.A.;
4. 9.33.4.4. - make-up air is required since there is an open fireplace; from Table 9.33.4.A. a 170 mm diameter duct is required for the 40 L/s bathroom fan and in this case it is provided to a storage room in the basement; and
5. 9.33.3.22. - doors to be undercut a minimum of 12 mm or a grille of an equivalent area provided.



(a) BASIC MECHANICAL VENTILATION SYSTEM - 0.5 A.C./H. WITH ANY HEATING SYSTEM

Example (b): shows a ventilation system utilizing a naturally-aspirating forced air heating system with a two-speed furnace fan as described in Article 9.33.3.14. A permitted alternate arrangement could utilize a dehumidistat which would control the furnace air circulating fan for the ventilation rate as required by Article 9.33.3.5. This is a combination heating/ventilating system where the furnace provides the heating as well as supplying the required house ventilation air. In this example, one air supply duct is provided to the return air plenum to provide both for the air supply as required by the furnace installation code and for the ventilation air required by Subsection 9.33.3. For this example the following would apply:

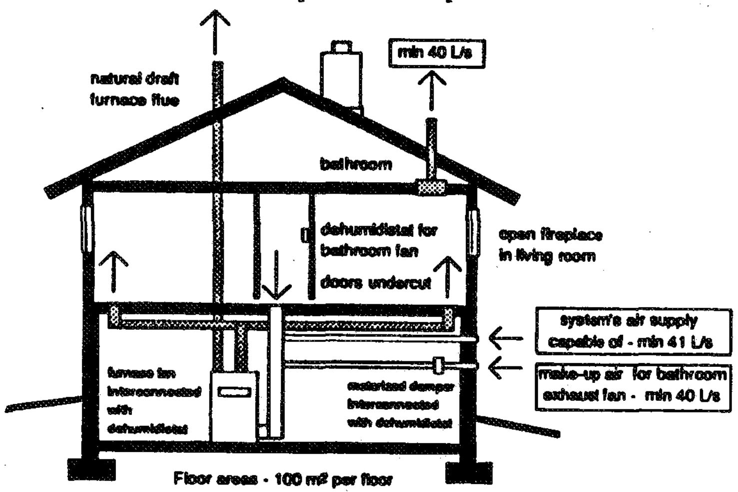
1. 9.33.3.14. - 0.3 air changes per hour or from Table 9.33.3.A. for 200 m^2 total heated floor area a minimum ventilation rate of 41 L/s is required;
2. 9.33.3.14. - minimum continuous ventilation rate of 20 L/s from Table 9.33.3.B. provided by the two-speed furnace fan;
3. 9.33.3.14. - the furnace and ventilation outdoor air supply provided by a 100 mm diameter duct directly to the return-air plenum from Table 9.33.3.C.;
4. 9.33.3.2. - the system design to Part 6, which also refers to ASHRAE handbooks and HRAI Digest for design of ventilation systems; and
5. 9.33.3.22. - doors to be undercut a minimum of 12 mm or a grille of an equivalent area provided.



(b) VENTILATION SYSTEM WITH A FUEL-FIRED FORCED AIR HEATING SYTEM - 0.3 A.C./H. AND CONTINUOUS VENTILATION

Example (c): shows a ventilation system utilizing a naturally-aspirating fuel-fired forced air heating system with a single speed furnace fan and a bathroom exhaust fan. In this example, an additional 100 mm make-up air duct with a motorized damper is provided to the return-air plenum for the make-up air required by the bathroom exhaust fan. This additional make-up air could also be provided by increasing the furnace air supply duct and installing a two-position motorized damper. For this example the following would apply:

1. 9.33.3.2. - 0.3 air changes per hour or from Table 9.33.3.A. for 200 m^2 total heated floor area a minimum ventilation rate of 41 L/s is required;
2. 9.33.3.5. - minimum ventilation rate controlled automatically of 40 L/s from Table 9.33.3.B., provided by bathroom exhaust fan;
3. 9.33.3.12. - make-up air is required since there is an open fireplace, this can be supplied through the forced air heating system by a separate 100 mm duct with a motorized interlocked damper as described in Article 9.33.3.12;
4. 9.33.3.2. - the system design to Part 6, which also refers to ASHRAE handbooks and HRAI Digest for design of ventilation systems; and
5. 9.33.3.22. - doors to be undercut a minimum of 12 mm or a grille of an equivalent area provided.



(c) VENTILATION SYSTEM WITH A FUEL-FIRED FORCED AIR HEATING SYTEM - 0.3 A.C./H. AND BATHROOM EXHAUST FAN

	Page	Reference	Revision
•	501	Appendix A	Add new Note: **A-9.33.3.4.** A mechanical ventilation system capable of operating on a year round basis is required for habitable rooms or spaces which do not have openable windows. The ventilation system for these rooms may be combined with the whole house ventilation system described in Articles 9.33.3.1. and 9.33.3.2. In most cases to comply with this requirement, an exhaust fan controlled by a switch or dehumidistat capable of providing 1 air change per hour (where summer cooling is not provided) based on the room or space volume would be required.
•	501	Appendix A	Add new Note: **A-9.33.3.5. Automatic Control.** This Article requires that the fan(s) of a required ventilation rate be controlled automatically by a centrally located dehumidistat. In a typical example, where the bathroom exhaust fan(s) are controlled by this centrally located dehumidistat, the exhaust fan(s) should also be controlled by a switch or timer located in the bathroom. In all cases the centrally located dehumidistat would be the overriding switch. For the most effective use of the dehumidistat, it is recommended that the setting be between 40% to 60% relative humidity to maintain a healthy environment and to control any potential moisture problems.

B.C. BUILDING CODE 1985

FIRST REVISIONS

SEPTEMBER 1988

Page	Reference	Revision
* 501	Appendix A	**A-9.33.3.7. Make-up air.** Make-up air is not required for the entire ventilation capacity only for the ventilation rate controlled automatically or provided continuously. However, in Article 9.33.3.13. additional separate make-up air is also required for any exhaust appliance with a capacity exceeding 0.5 air change per hour. This acknowledges the fact that although houses are being built tighter there is still enough air leakage through the envelope that can provide the additional air requirements of approximately 50L/s to 100L/s at 5 Pa, depending on the size of the house. This is based on a leakage rate or NLA of 1.08 cm^2/m^2 as established by a BETT/EMR survey of airtightness of housing across Canada. The 5 Pa depressurization has been established as the maximum permitted depressurization to prevent backdrafting of naturally-aspirating appliances.

| - indicates N.R.C. errata (issued January 1988)

*- indicates B.C. errata

Note: N.R.C. issued revisions (or errata) do not automatically become part of the B.C. Building Code, they must be adopted by the Province.

BRITISH COLUMBIA BUILDING CODE 1985

FIRST ERRATA

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Recreation and Culture
Parliament Buildings
Victoria B.C. V8V 1X4
(604) 387-4010

September 1988

9.32.5.3. Where a public sewage system is not available, the *building* sewer shall discharge into a *private sewage disposal system*.

SUBSECTION 9.32.6. SERVICE WATER HEATING FACILITIES

Service water heating facilities

9.32.6.1. Where a hot water supply is required by Article 9.32.4.3., equipment shall be installed to provide to every *dwelling unit* an adequate supply of service hot water with a temperature range from 60°C to 75°C.

Distribution of service hot water

9.32.6.2. Service hot water may be distributed from a centrally located heater to supply the entire *building* or may be supplied by an individual *service water heater* for each *dwelling unit*.

Installation

9.32.6.3. Every *service water heater* and its installation shall conform to Part 6.

Storage tanks

9.32.6.4. Where storage tanks for *service water heaters* are of steel, they shall be coated with zinc, vitreous enamel (glass lined), hydraulic cement or other corrosion-resistant material.

Fuel-burning service water heaters

9.32.6.5. Fuel-burning *service water heaters* shall be connected to a *chimney flue* conforming to Section 9.21.

Heating coils

9.32.6.6. Heating coils of *service water heaters* shall not be installed in a *flue* or in the combustion chamber of a *boiler* or *furnace* heating a *building*.

SECTION 9.33 VENTILATION

SUBSECTION 9.33.1. GENERAL

Scope

9.33.1.1. This Section applies to the ventilation of rooms and spaces in *residential occupancies* by natural ventilation and to self-contained mechanical ventilation systems serving only 1 *dwelling unit*.

9.33.1.2. Mechanical ventilation systems serving more than 1 *dwelling unit* shall conform to Part 6.

Non-residential buildings

9.33.1.3. Ventilation of rooms and spaces in other than *residential occupancies* shall conform to Part 6.

Storage garages

9.33.1.4. A *storage garage* for more than 5 cars shall be ventilated in accordance with Part 6.

9.33.1.5. Rooms or spaces in *dwelling units* shall be ventilated during the non-heating season by natural means in accordance with Subsection 9.33.2. or by a mechanical ventilation system conforming to Subsection 9.33.3.

9.33.1.6. A space that contains a fuel-fired heating *appliance* shall be provided with combustion air in accordance with Section 9.34.

SUBSECTION 9.33.2. NATURAL VENTILATION

Minimum natural ventilation area

9.33.2.1. The unobstructed ventilation area to the outdoors for rooms and spaces in residential *buildings* ventilated by natural means shall conform to Table 9.33.2.A. Where a vestibule opens directly off a living or dining room within a *dwelling unit*, ventilation to the outdoors for such rooms may be through the vestibule.

Table 9.33.2.A.
Forming Part of Article 9.33.2.1.

NATURAL VENTILATION		
Location		Minimum Unobstructed Area
Within *dwelling unit*	Bathrooms or water-closet rooms	$0.09\ m^2$
	Unfinished *basement* space	0.2 per cent of the floor area
	Dining rooms, living rooms Bedrooms, kitchens, combined rooms Dens, recreation rooms and all other finished rooms	$0.28\ m^2$ per room or combination of rooms
Other than within *dwelling unit*	Bathrooms or water-closet rooms	$0.09\ m^2$ per water-closet
	Sleeping areas	$0.14\ m^2$ per occupant
	Laundry rooms, kitchens, recreation rooms	4 per cent of the floor area
	Corridors, storage rooms and other similar public rooms or spaces	2 per cent of the floor area
	Unfinished *basement* space not used on a shared basis	0.2 per cent of the floor area
Column 1	2	3

Protection of openings supplying natural ventilation

9.33.2.2. Openings for natural ventilation other than windows shall be constructed to provide protection from the weather and insects. Screening shall be of rust-proof material.

SUBSECTION 9.33.3. MECHANICAL VENTILATION

Mechanical ventilation required

9.33.3.1. *Dwelling units* shall have a mechanical ventilation system capable of providing at least one half an air change per hour during the heating season, based on the interior finished volume of the *dwelling unit*. The system shall be controlled either manually by a switch or automatically. (See Appendix A.)

9.33.3.2. Where rooms or spaces in *dwelling units* are provided with mechanical ventilation systems in lieu of natural ventilation as required in Article 9.33.1.5., the systems shall be capable of providing at least 1 air change per hour where summer cooling is not provided or at least half an air change per hour where summer cooling is provided.

Make-up air

9.33.3.3. Mechanical ventilation systems for *dwelling units* shall include provision for introduction of fresh make-up air from the exterior.

9.33.3.4. Mechanical ventilation systems in combination with central heating or cooling systems shall conform with Part 6.

Exhaust discharge

9.33.3.5. *Exhaust ducts* shall discharge directly to the outdoors. Where the *exhaust duct* passes through or is adjacent to unheated space, the duct shall be insulated to prevent moisture condensation in the duct.

Access to ventilation equipment

9.33.3.6. Ventilation equipment shall be accessible for inspection, maintenance, repair and cleaning. Kitchen *exhaust ducts* shall be designed and installed so that the entire duct can be cleaned where the duct is not equipped with a filter at the intake end.

Air intake shield

9.33.3.7. Outdoor air intake and exhaust outlets shall be shielded from weather and insects. Screening shall be of rust-proof material.

9.33.3.8. Ventilating ducts shall conform to the requirements of Part 6 for *supply ducts*, except *exhaust ducts* that serve only a bathroom or water-closet room may be of *combustible* material provided the duct is reasonably air tight and constructed of a material impervious to water.

SECTION 9.34 HEATING AND AIR-CONDITIONING

SUBSECTION 9.34.1. GENERAL

Central heating systems

9.34.1.1. The design and installation of central heating systems shall conform to the requirements in Part 6 and to this Section. (See also Subsection 9.10.10.)

Air-conditioning systems

9.34.1.2. The design and installation of air-conditioning systems shall conform to the requirements in Part 6.

Temperature in buildings

9.34.1.3. Residential *buildings* intended for use in the winter months on a continuing basis shall be equipped with heating facilities capable of maintaining an indoor air temperature of 22°C at the outside winter design temperature except as provided in Article 9.34.1.4. All other *buildings* shall be equipped with heating facilities of sufficient capacity to maintain the desired indoor air temperature, commensurate with the use of the *building*, at the outside winter design temperature. Winter design temperatures shall be determined in conformance with Subsection 2.2.1.

Temperature in basement

9.34.1.4. Heating facilities shall be provided which shall be capable of maintaining a temperature of not less than 18°C in an unfinished *basement* in *buildings* of *residential occupancy*. Where crawl spaces are required to be heated, the heating facilities shall be capable of maintaining a temperature of not less than 15°C.

A-9.33.3.1. Mechanical Ventilation. The tendency toward achieving higher levels of airtightness in housing and other concerns over energy conservation indicate that natural ventilation is not sufficient to ensure acceptable air quality during the winter heating season. The mechanical system required by this Article is, therefore, independent of natural sources, including windows and air infiltration.

This Article does not require that a centralized ventilation system be provided with duct work leading to all parts of the dwelling unit. The requirement may be satisfied by means of exhaust fans located in kitchen or bathroom areas where a fresh air inlet is provided at a location remote from the exhaust outlet. A ventilation system operating in conjunction with a central heating or cooling system comes under the jurisdiction of Part 6.

A-9.34.1.7. Combustion Air and Tight Houses. The operation of an air exhaust system or of a fuel-burning appliance removes the air from a house, creating a slight negative pressure inside. In certain cases the natural flow of air up a chimney can be reversed, leading to a possible danger of carbon monoxide poisoning for the inhabitants.

Newer houses are generally more tightly constructed than older ones because of improved construction practices, including tighter windows, weather stripping and caulking. This fact increases the probability that infiltration may not be able to supply enough air to compensate for simultaneous operation of exhaust fans, fireplaces, clothesdryers, furnaces and space heaters. Further information is available in Canadian Building Digest 222, "Airtight Houses and Carbon Monoxide Poisoning," available from the Division of Building Research, National Research Council of Canada, Ottawa K1A 0R6.

A-9.34.2. Installation of Stoves, Ranges and Space Heaters Burning Solid Fuel. Where tests show that minimum clearances or mounting techniques other than as specified will result in an equivalent level of safety, they are permitted under the provisions of Section 2.5. Where test results show that appliances must be installed with minimum clearances greater than specified in Subsection 9.34.2., the greater clearances should be maintained.

Table #1: Ventilation Rates

ROOM TYPE	CONTINUOUS VENTILATION	INTERMITTENT EXHAUST		CONTINUOUS EXHAUST
Double/Master Bedroom	20 CFM(10 L/S)			
Basement	20 CFM(10 L/S)			
Single bedrooms	10 CFM(5L/S)			
Living room	10 CFM(5L/S)			
Dining room	10 CFM(5L/S)			
Family room	10 CFM(5L/S)			
Recreation room	10 CFM(5L/S)			
Other habitable rooms	10 CFM(5L/S)			
Kitchen	10 CFM(5L/S)	100CFM(50L/S)	OR	60CFM(30L/S)
Bathrooms	10 CFM(5L/S)	50CFM(25L/S)	OR	30CFM(15L/S)
Laundry	10 CFM(5L/S)			
Utility	10 CFM(5L/S)			

Quality Plus Program Partners

Canadian Home Builders' Association of British Columbia

Represented by:
Mr. Brian Usher
President, CHBA-BC
Branta Fine Homes Inc.

Derick Turner
Quality Plus Program
Director; CHBA-BC

BC hydro

Represented by:
Mr. Murray Bond
Residential Marketing
Manager; B.C. Hydro

Mr. George Pinch
Energy Management
Engineer; B.C. Hydro

BC Gas Naturally.

Represented by:
Mr. Bill Arthur
Director, Market Planning
B.C. Gas Inc.

Ms. Wendy McEvoy
Residential Marketing
Manager; B.C. Gas Inc.

New Home Warranty Program of British Columbia and the Yukon

Represented by:
Mr. David Verge
Chief Executive Officer
New Home Warranty
Program of B.C. and the
Yukon

R2000

Represented by:
CHBA National, and
Energy, Mines &
Resources, Canada

West Kootenay Power

Represented by:
Mr. Steve Ash
Manager, Commercial
Affairs; West Kootenay
Power & Light

The French "AERECO" Proportional Negative Pressure System

Excerpt from 1982 Building Code, France:

Chapter 1 Built-in General Ventilation

Art. 2 - Ventilation system components

Air inlets must be used in all principal rooms (PR) ducted to the outside wall, whether passive or mechanical ventilation.

Air outlets are located in the technical rooms, (TR) kitchen, bathrooms and toilets, and must be connected to vertical ducts for passive ventilation or ducted to a fan for mechanical ventilation. For multi- family buildings, if one technical room is mechanically ventilated all must be mechanically ventilated.

Intake air must move freely from the principal rooms to the technical rooms.

If one room is used as a principal room and a technical room (Like a bedroom with cooking equipment), it must have one air inlet and one air outlet.

Art. 3 - Ventilation systems, whether mechanical or passive, must be capable of the following extracted airflow as shown below at moderate winter temperatures.

The extracted airflow from each technical room must meet the following installed capacity requirements simultaneously according to the number of principal rooms.

PEAK EXHAUST CAPACITY REQUIRED

Number of Principal Rooms	Main Kitchen	Bathroom with or without toilet	Additional Bathrooms	Unique if House has only one toilet	if house has more than one toilet
1	75m3/h	15	15	15	15
2	90	15	15	15	15
3	105	30	15	15	15
4	120	30	15	30	15
5+	135	30	15	30	15

N.B. Kitchen extractor set to these rates when string is pulled.

In the dwellings where there is only one main room, the bathroom and toilet, when they are separated by a wall but are side by side, may be served by one extractor only located in the toilet room, and the extractor must draw 15 m3/h.

In the absence of a wall between the bedroom and a living room, this room is considered as two principal rooms.

If a range hood is installed, less ventilation is required. The additional amount required is determined by the efficiency of the hood and approval of the ministry of construction and ministry of health.

The toilets are considered multiple if at least two are used in the dwelling even if one is located in the main bathroom.

Article 4 modified 28.10.1983

Art. 4 - Individual adjustment devices will be allowed to reduce the airflow of article 3 under the following conditions:

In general terms, the total dwelling exhaust and the kitchen exhaust may be reduced to the following figures.

<u>1982 LAW CONSTANT FLOW</u>

If a constant flow system is used rates must be a minimum of (30 + 15 x #PR)

	NUMBER OF PRINCIPAL ROOMS						
	1	2	3	4	5	6	7
<u>Minimum continuous</u> total exhaust in dwelling (m3/h)	35	60	75	90	105	120	135
Continuous minimum (CFM)	20	35	43	51	60	68	77
Minimum continuous exhaust in kitchen (m3/h)	20	30	45	45	45	45	45
Continuous minimum (CFM)	11	17	26	26	26	26	26

If a system is mechanical, if automatic, if it will control pollution and condensation except for brief periods, the following reduction is possible.

The use of this reduced airflow system must be approved by the minister of construction and the minister of health.

The total extraction rate must be at least as follows:

	NUMBER OF PRINCIPAL ROOMS						
	1	2	3	4	5	6	7
# of extractors required:	1	1	1	2	2	2	3
Minimum continuous total exhaust:	10	10	15	20	25	30	35
Continuous minimum (CFM)	6	6	9	11	14	17	20

Art. 5 The air inlets plus the equivalent leakage area must allow enough make-up air to achieve the required rates outlined in article 3.
Note: cfm = .57 x m3/h

APPENDIX 3

AIR QUALITY INDEX

CO_2 INDOOR AIR QUALITY INDEX

The index below is an arbitrary index developed for this project and is based upon the CO_2 data accumulated. The following quote from the recent ASHRAE 62-1989 Ventilation Standard provides some justification:

> Carbon dioxide concentration has been widely used as an indicator of indoor air quality. Comfort (odour) criteria are likely to be satisfied if the ventilation rate is set so that 1,000 ppm CO_2 is not exceeded.

The index below gives equal authority to average CO_2 concentrations, maximum concentrations, and percent of time that CO_2 levels exceeded 800 ppm. The 800 ppm level was chosen because levels, particularly in the first year, were generally low, and because it is generally agreed that IAQ problems can start at 800 ppm.

Each period's data was averaged into the calculations. The lower the index, the better the IAQ.

SYSTEM	Av.CO2	Max CO2	% >800ppm	INDEX
NEG.CR.L	567	1033	1%	0.32
NEG.CR.DH	604	915	0%	0.31
POS.CR.L	607	1106	10%	0.38
POS.CR.DH	745	1176	20%	0.47
HRV LOW	1120	2413	75%	1.00
HRV HI	820	1698	36%	0.64
AERECO 1	1000	1579	51%	0.74
CODE L	699	1263	50%	0.60
CODE DH	847	1807	43%	0.69
WALL PIPE L	820	1481	62%	0.72
WALL PIPE DH	888	1447	67%	0.76
WALL INLET LOW	788	1215	63%	0.68
WALL INLET DH	741	1348	45%	0.61
DA HRV .15ACH	806	1476	34%	0.59
DA +ded.air	924	1021	51%	0.64
DA HRV F326	724	1009	24%	0.46

APPENDIX 4.

SUMMARY CHART FOR RESULTS

WESTCOAST VENTILATION STUDY; FIRST YEAR DATA SUMMARY; APRIL, 1989

NOTE: "L" denotes 0.15 ACH; "DH" denotes 0.3 ACH by dehumidistat; TLV denotes threshold limit value

SYSTEM	NEG.CRWLSP		POS.CRWLS		HRV		AERECO		CODE		WALL PIPE		WALL INLET		HWC	TLV
—	L	DH	L	DH	LOW	HI	1	2	L	DH	L	DH	L	DH		
NUMBER OF OCCUPANTS	4	4	4	4	5	5	3	3	3	3	4	4	4	4		
OCCUPANCY (Hi/Med/Low)	L	L	L	L	H	H	M	L	L	L	L	M	H	H		
OCCUPANT SATISFACTION	H		H		H		H		M		H		H			
MECHANICAL CFM	74	148	74	148	50	115	-	-	23	46	23	46	21	41		
INSTALLATION COST	$300		$375		$1,550		$1,300		$375		$500		$400			
OPERATING COST/YR	$177	$10	$177	$16	$54	$115	$68	$90	$101	$130	$58	$16	$55	$2		
EQUIV. LEAKAGE AREA	abv range		1052		347.4		386.4		424.		386		446.9			
TRACER GAS CALC'D ACH				0.46		0.48	0.33	0.33				0.57		0.46		
FAN ON TIME	100%	3%	100%	5%	100%	100%	100%	100%	100%	98%	100%	12%	100%	2%		
AV SPACE TEMP (DEG.C)	19	20	17	19	23	22	22	19	18	18	25	25	22	23		
AV SPACE REL HUM %	50	52	50	51	40	41	50	58	58	58	45	44	44	43		
AV SPACE CO2 (ppm)	567	604	607	745	859	687	950	672	716	662	939	1019	789	714		
AV OUTDOOR TEMP (C)	5.4	3.5	-2.2	3.4	1.7	3.2	6.4	5.1	6.4	5.1	6.4	5.1	6.4	5.1		
TIME OF RH > 70 %	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%		
TIME OF CO2 > 800 ppm	1%	0%	10%	20%	43%	17%	64%	29%	25%	18%	68%	83%	28%	16%		
MIN SPACE TEMP (C)	17	18	12	16	21	20	19	13	14	13	22	24	21	20		
MIN SPACE RH %	43	48	46	45	36	38	42	41		47	39	39	37	38		30
MIN SPACE CO2 (ppm)	406	415	400	406	485	485	383	394	410	394	410	394	410	413		
MIN OUTDOOR TEMP (C)	3	0.8	-10.	-0.4	-3.2	-1.2	4.4	3.5	4.4	3.5	4.4	3.5	4.4	3.5		
MAX SPACE TEMP (C)	22	21	22	22	26	24	26	25	23	23	27	28	25	25		
MAX SPACE RH %	55	55	55	56	68	49	59	68	76	70	51	50	54	51		55
MAX SPACE CO2 (ppm)	1033	915	1106	1176	1290	1177	1421	1252	1206	1186	1650	1441	1200	1209		3500
MAX OUTDOOR TEMP (C)	7.9	6.9	8	7	6.2	7	8.9	7.1	8.9	7.1	8.9	7.1	8.9	7.1		
MAX CO (SPOT CHECKS)	4	4	3	3	3	3	5	6	12	5	6	5	5	5		25
KITCHEN HOOD CFM	120		120		165		50		75		25		150			
FORMALDEHYDE (ppm)	0.04		0.1		0.1		0.04		0.04		0.1		0.04			0.05
NITROGEN DIOXIDE (ppm)	0		0		0		0		0		0		0			0.052

WESTCOAST VENTILATION STUDY: SECOND YEAR DATA SUMMARY - JUNE 18, 1990

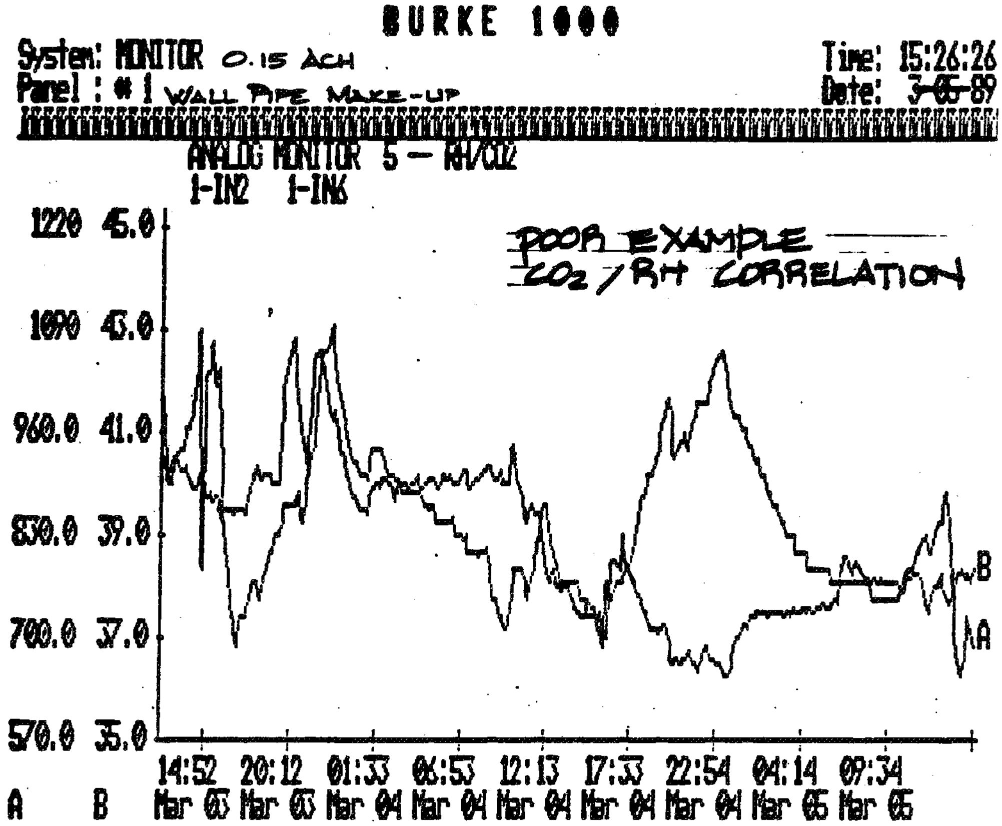
NOTE: "D.O.M." denotes DAILY OUTDOOR MEAN temperature
"DA" denotes dedicated air 0.15 ACH

SYSTEM	HRV	HRV	AIRRECO	AIRRECO	CODE	CODE	WALL PIPE		WALL INLET		DEDICATED		AIR
	LOW	HI	1	2	L	DH	L	DH	L	DH	L	DA	HIGH
NUMBER OF OCCUPANTS	10	9	3	3	3	3	3	3	3	3	6	6	6
OCCUPANCY (cu.ft./person)	977	977	2733	2733	3069	3069	3257	3257	2733	2733	3983	3983	3983
OCCUPANT SATISFACTION	H		H		M			H	H		L	L	H
MECHANICAL CFM	50	115	-	-	23	46	23	46	21	41	60	60	140
MECHANICAL ACH	0.31	0.71	0.18	0.18	0.15	0.3	0.15	0.3	0.15	0.3	0.15	0.15	0.35
INSTALLATION COST	$1,860		$1,560		$450		$600		$480		$2,200	$2,500	$2,500
OPERATING COST/SQ.FT. YR	$0.046	$0.098	$0.070	$0.070	$0.092	$0.118	$0.053	$0.015	$0.047	$0.002	$0.027	$0.027	$0.044
EQUIV. LEAKAGE AREA	347.4		386.4		424.9		386		446.9				
TRACER GAS CALC'D ACH		0.48	0.33	0.33			0.57			0.46			
FAN ON TIME	100%	100%	100%	100%			100%		100%		100%	100%	100%
KITCHEN HOOD CFM	165		50		75		25		150		-		
FORMALDEHYDE (ppm)	undetectable		not sampled		not sampled		undetectable		not sampled		not sampled		
MAIN LIVING AREA													
AV SPACE TEMP (DEG.C)	23.2	22.5	18.6	20.5	19.4	20.4	22.7	22.0	22.3	22.0	22.6	22.5	22.9
AV SPACE REL HUM %	44.8	46.3	51.0	50.1	48.7	50.8	42.9	43.9	37.4	37.6	41.9	45.0	41.9
AV SPACE CO2 (ppm)	1355.5	997.8	989.7	1076.9	820.5	784.5	836.9	825.8	882.4	675.9	726.6	-	645.2
MEAN OUTDOOR TEMP (C)	8.3	10.7	6.2	8.9	6.2	8.9	8.9	6.2	6.2	8.9	6.0	9.3	3.6
MIN SPACE TEMP (C)	21.8	19.8	13.7	17.7	16.3	17.2	20.5	17.2	18.3	18.9	20.1	20.5	19.2
MIN SPACE RH %	41.8	40.2	43.0	44.1	41.2	40.3	39.7	37.7	29.5	28.1	39.3	41.4	38.1
MIN SPACE CO2 (ppm)	519.5	339.3	425.0	509.0	436.8	464.3	402.5	559.5	472.0	413.5	566.0	-	475.5
MIN D.M.O. TEMP (C)	8.3	11.7	6.2	8.9	6.2	8.9	8.9	6.2	6.2	8.9	3.3	7.8	3.3
MAX SPACE TEMP (C)	24.8	25.5	22.6	22.9	23.1	26.0	25.5	26.5	24.9	24.9	23.8	26.4	25.0
MAX SPACE RH %	50.6	55.9	59.8	57.4	66.3	61.4	48.4	52.4	43.5	43.6	45.2	60.9	61.5
MAX SPACE CO2 (ppm)	2932.0	2174.0	1951.0	1661.0	1569.0	1410.0	1605.0	1455.0	1303.0	1396.0	957.0	-	838.0
MAX D.M.O. TEMP (C)	8.7	10.7	9.0	9.9	9.0	9.9	9.9	9.0	9.0	9.9	8.2	10.5	4.3
TIME OF RH > 70 %	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MAIN - TIME OF CO2>800 ppm	98%	66%	55%	43%	67%	52%	49%	66%	58%	52%	18%	-	3%

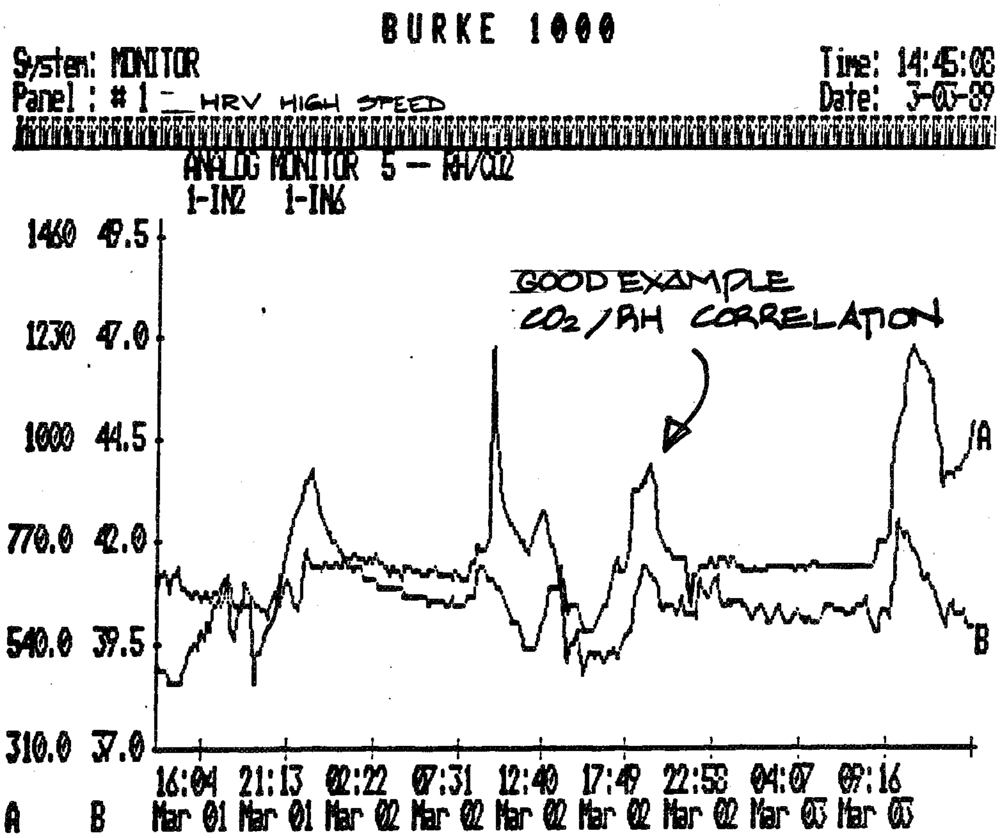
SYSTEM	HRV	HRV	AERECO	AERECO	CODE	CODE	WALL PIPE		WALL INLET			DEDICATED	AIR
	LOW	HI	1	2	L	DH	L	DH	L	DH	L	DA	HIGH
BEDROOM													
AV SPACE TEMP (DEG.C)	21.2	22.3	20.7	21.3	19.5	19.3	21.6	23.6	21.8	22.1	20.5	20.7	20.3
AV SPACE REL HUM %	46.4	46.6	51.3	46.9	50.8	57.0	45.3	41.4	38.3	39.4	47.8	49.5	46.7
AV SPACE CO2 (ppm)	1144.1	774.5	1151.6	1158.9	605.2	1095.1	683.5	817.9	692.5	834.4	884.3	924.3	802.0
AV OUTDOOR TEMP (C)	9.7	12.6	8.7	9.1	8.7	9.1	9.1	8.7	8.7	9.1	6.0	9.3	3.6
MIN SPACE TEMP (C)	18.6	20.7	18.4	18.5	17.0	17.7	18.8	20.7	18.9	19.5	18.3	19.5	17.8
MIN SPACE RH %	42.9	41.4	40.9	41.4	45.1	49.9	40.3	38.7	31.8	33.2	42.5	44.8	40.6
MIN SPACE CO2 (ppm)	431.0	396.8	818.5	606.0	410.0	519.0	460.3	367.8	393.0	443.8	559.0	486.0	445.0
MIN D.M.O. TEMP (C)	8.1	9.1	7.8	8.4	7.8	8.4	8.4	7.8	7.8	8.4	3.3	7.8	3.3
MAX SPACE TEMP (C)	23.8	24.1	23.9	24.1	21.5	21.6	24.7	25.6	24.7	25.8	23.5	23.3	23.0
MAX SPACE RH %	55.1	55.7	58.3	56.9	56.7	78.9	50.4	46.5	42.5	43.5	55.9	56.7	62.4
MAX SPACE CO2 (ppm)	3016.0	1744.0	1295.0	1894.0	1014.0	2826.0	1189.0	1454.0	1142.0	1439.0	1994.0	1141.0	1179.0
MAX D.M.O. TEMP (C)	12.1	15.6	9.4	9.9	9.4	9.9	9.9	9.4	9.4	9.9	8.2	10.5	4.3
TIME OF RH > 70 %	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
BEDRM - TIME OF CO2>800 ppm	84%	37%	53%	59%	48%	58%	69%	53%	47%	68%	50%	82%	45%

APPENDIX 5.

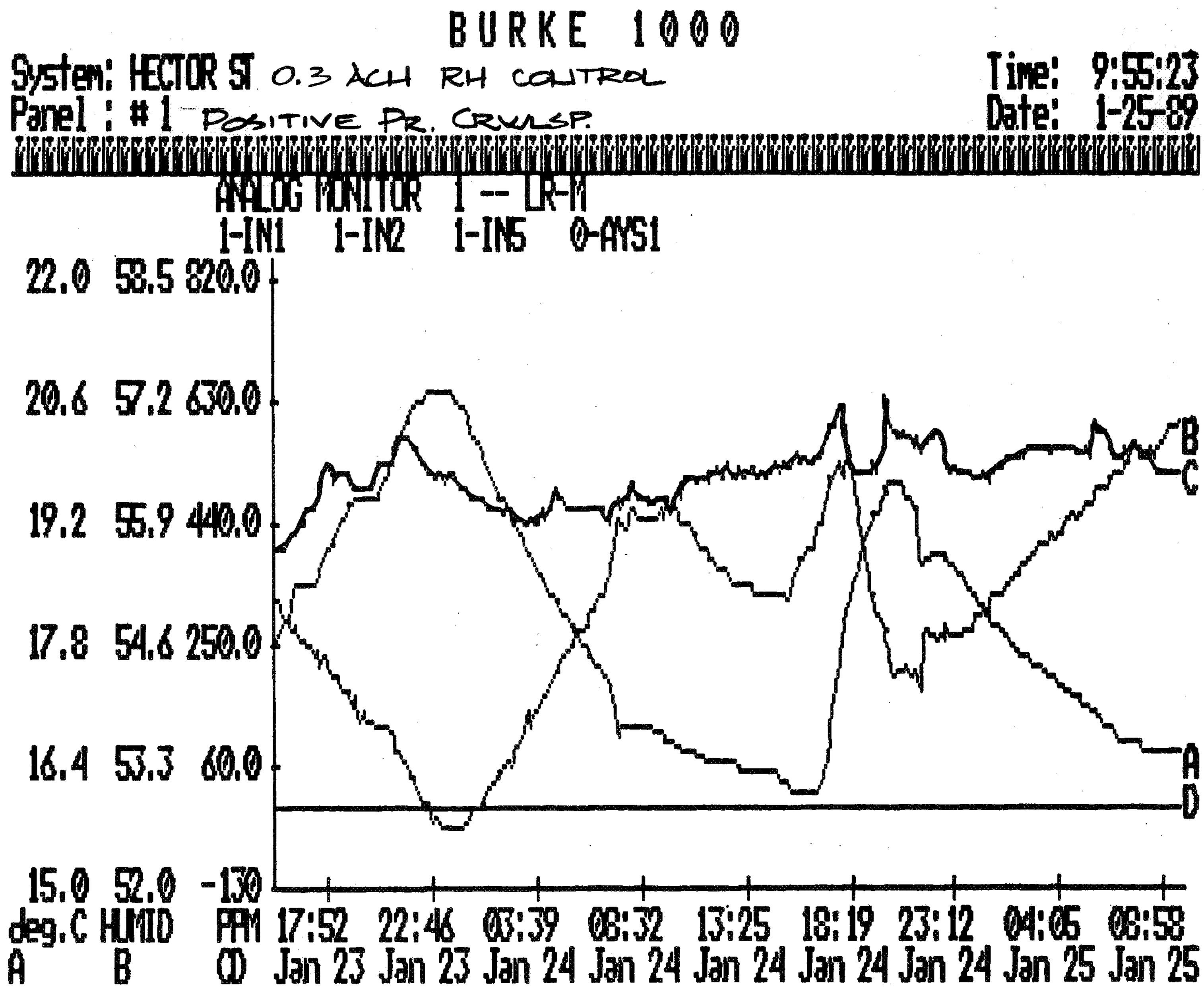
REAL TIME GRAPHS OF MONITORING



FIRST YEAR DATA



FIRST YEAR DATA



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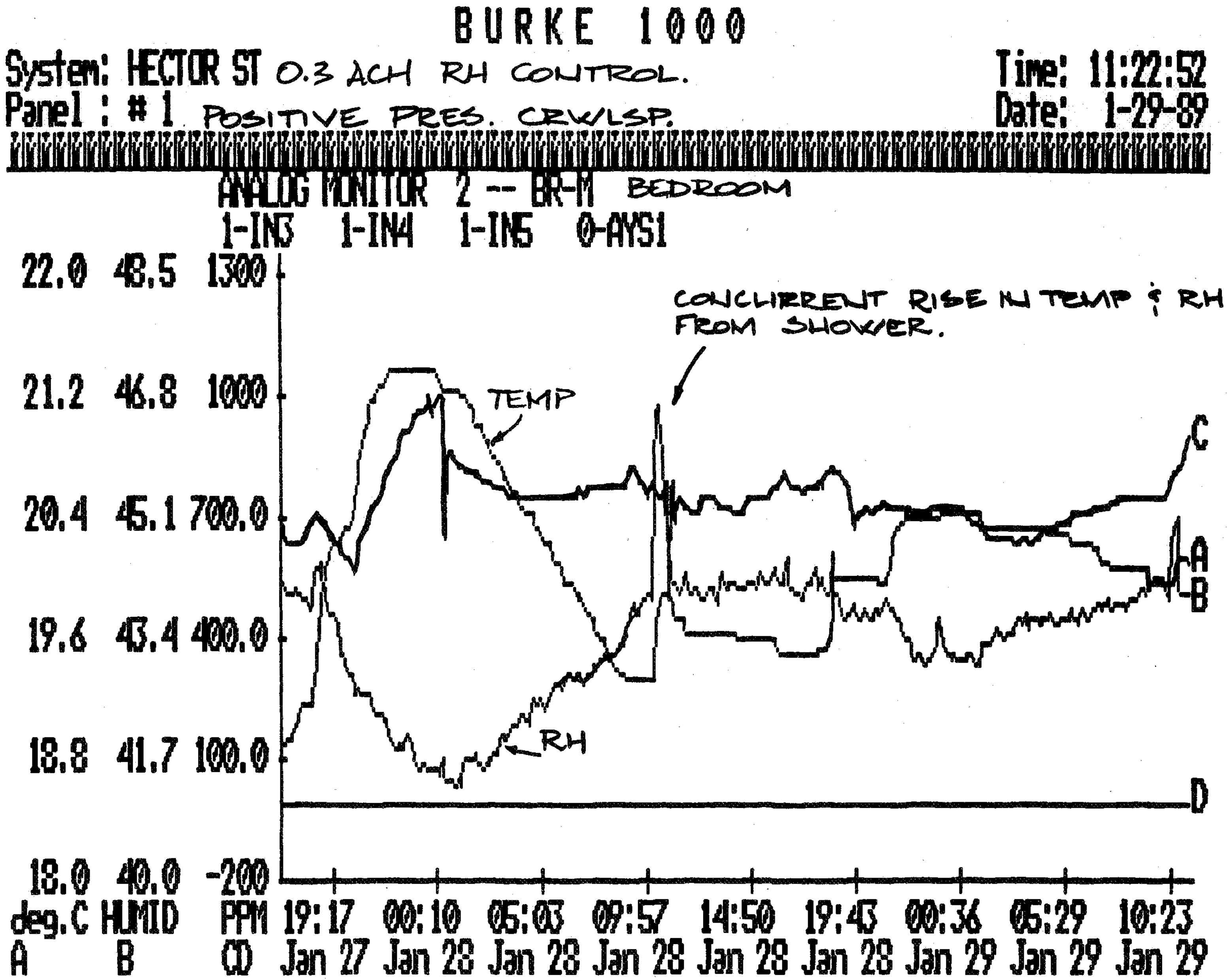
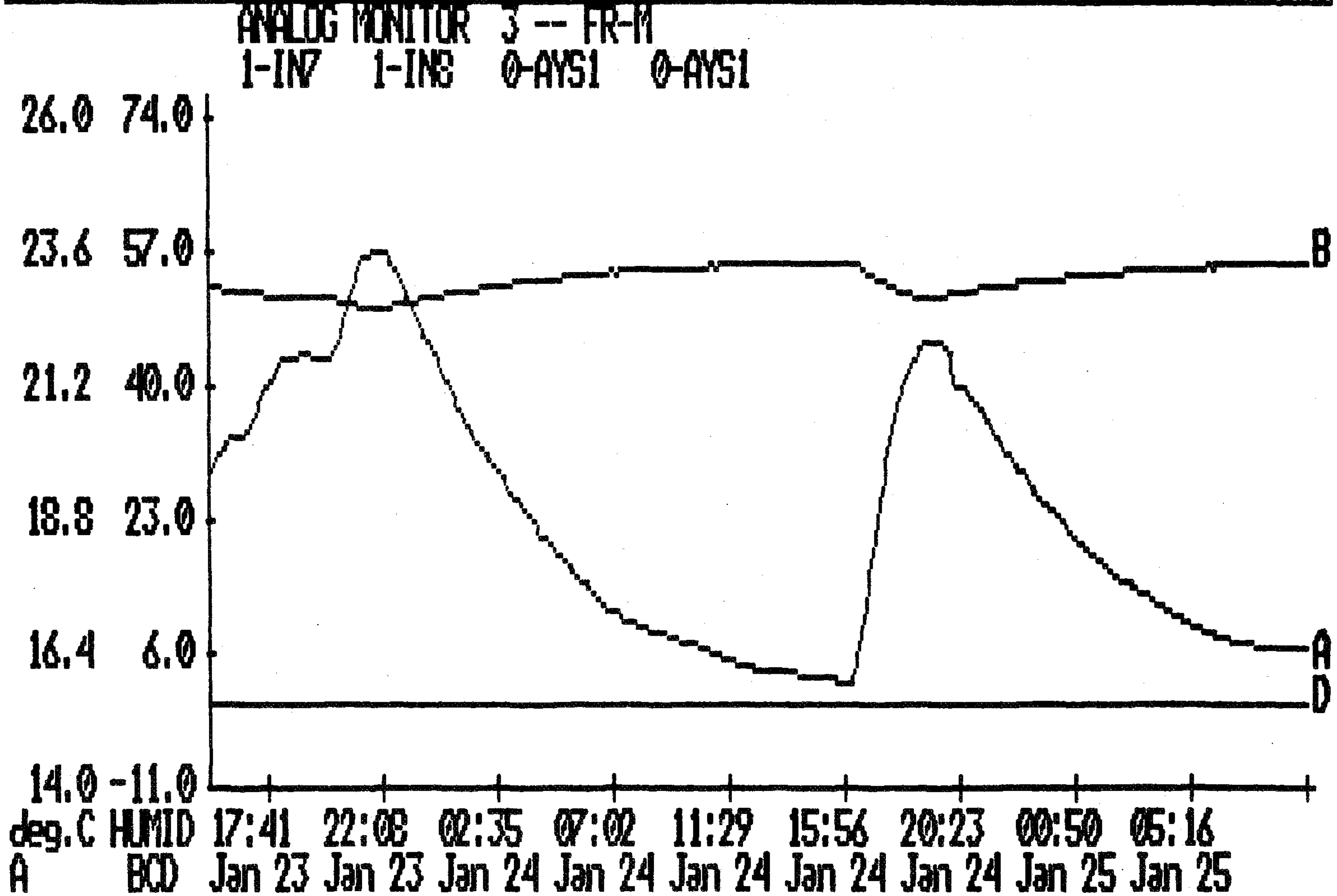


FIRST YEAR DATA

BURKE 1000

System: HECTOR ST　　　　Time: 10:03:47
Panel : # 1　POS CRWLSP. DH CONTROL　　　　Date: 1-25-89

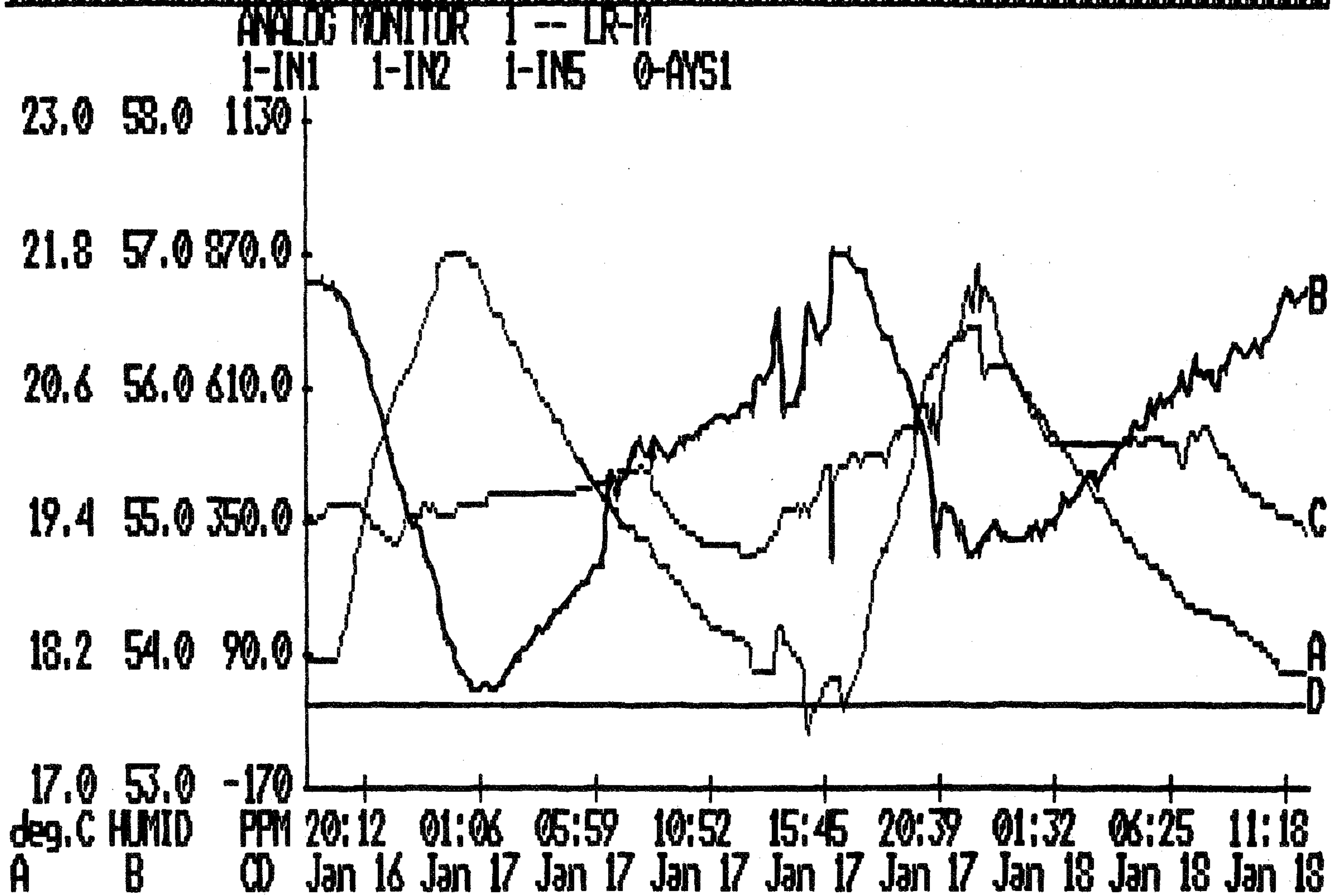


FIRST YEAR DATA

BURKE 1000

System: HECTOR ST 0.15 ACH
Time: 12:19:22

Panel : # 1 NEG. PRES. CRWLSP.
Date: 1-18-89

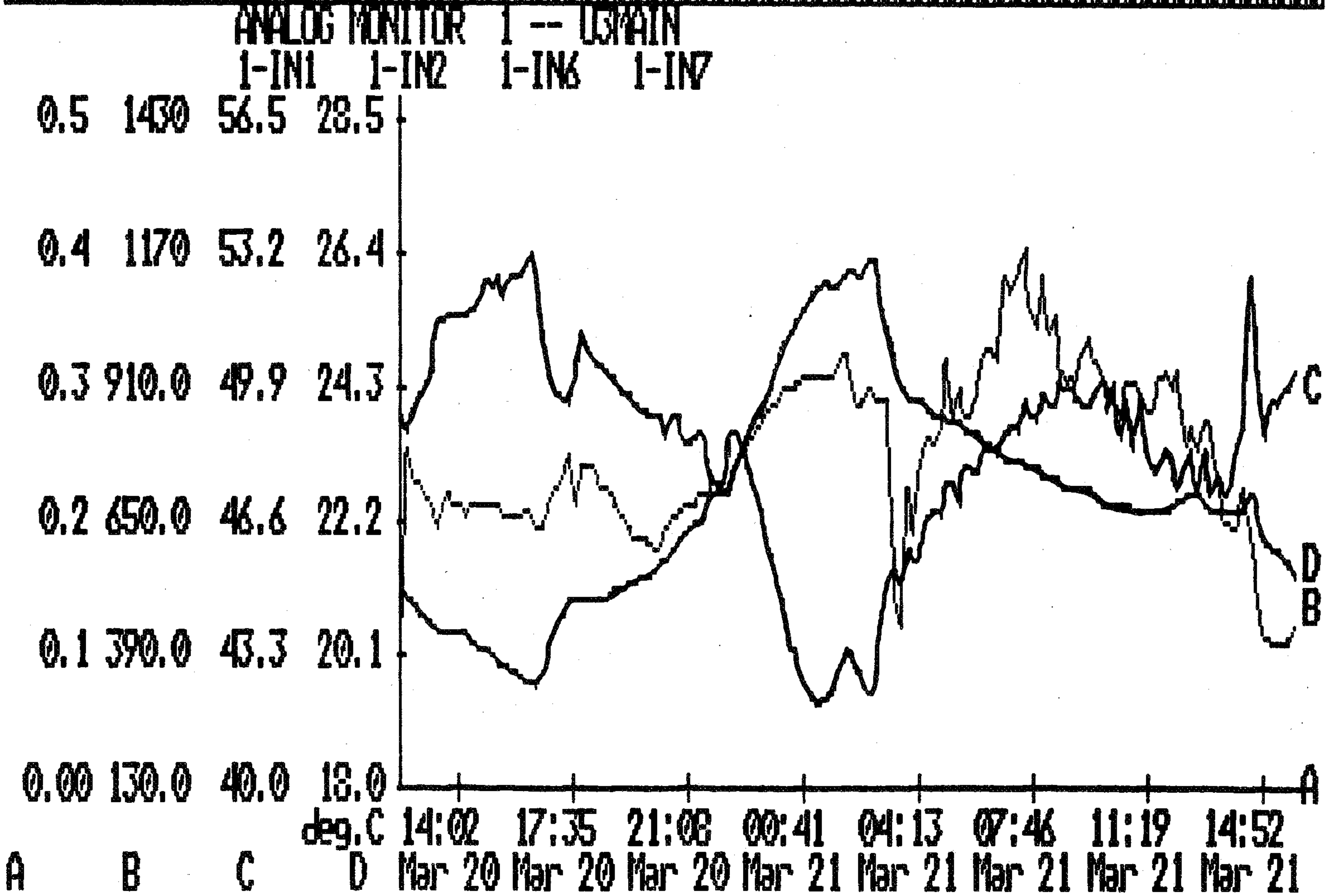


FIRST YEAR DATA

BURKE 1000

System: AERECO
Panel : # 1 WEEK 1

Time: 16:13:29
Date: 3-21-89



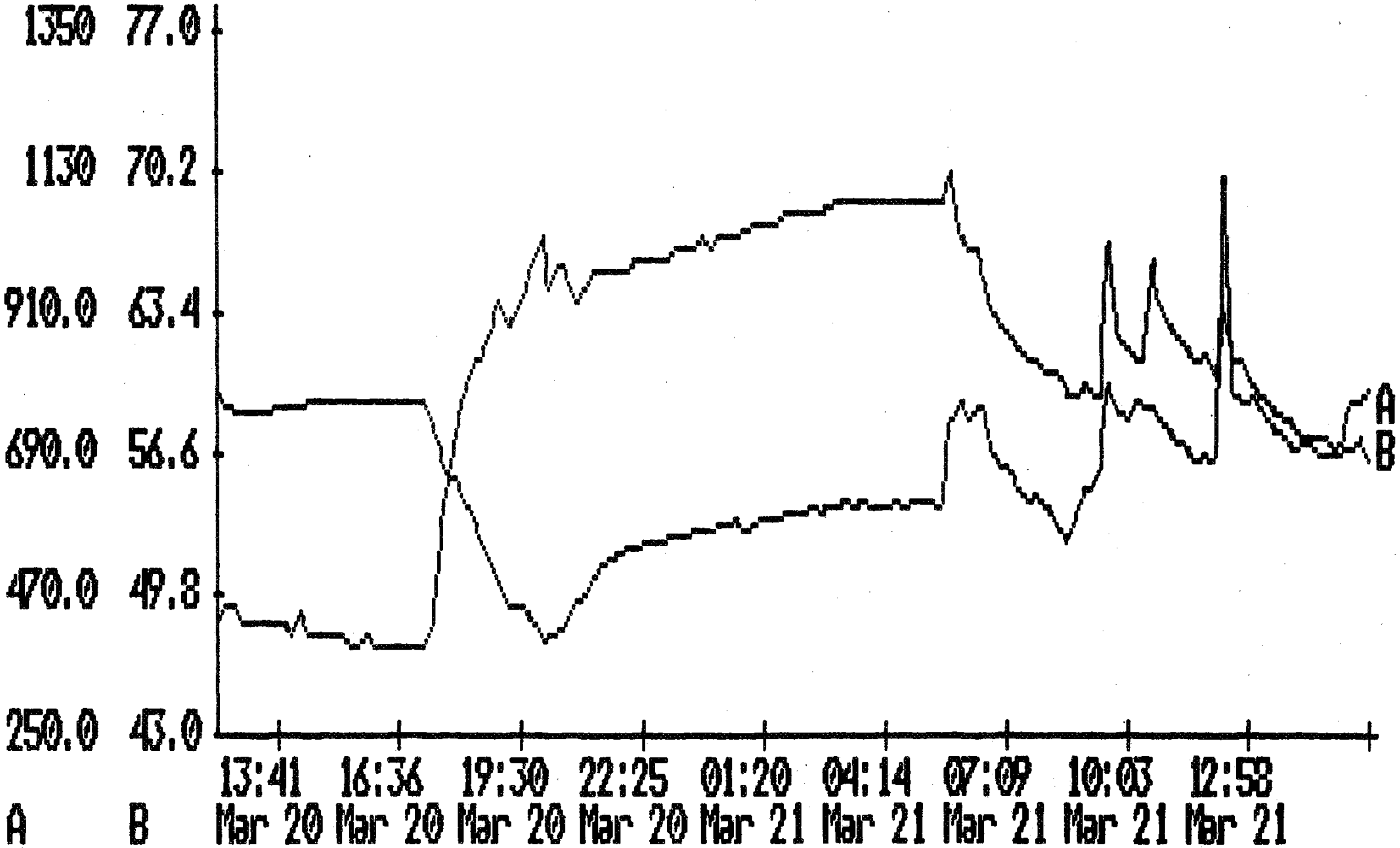
FIRST YEAR DATA

BURKE 1000

System: 0.15 ACH
Panel : # 1 '85 CODE HOUSE

Time: 16:16:21
Date: 3-21-89

ANALOG MONITOR 5 -- U4CO2/RH
1-IN2 1-IN9

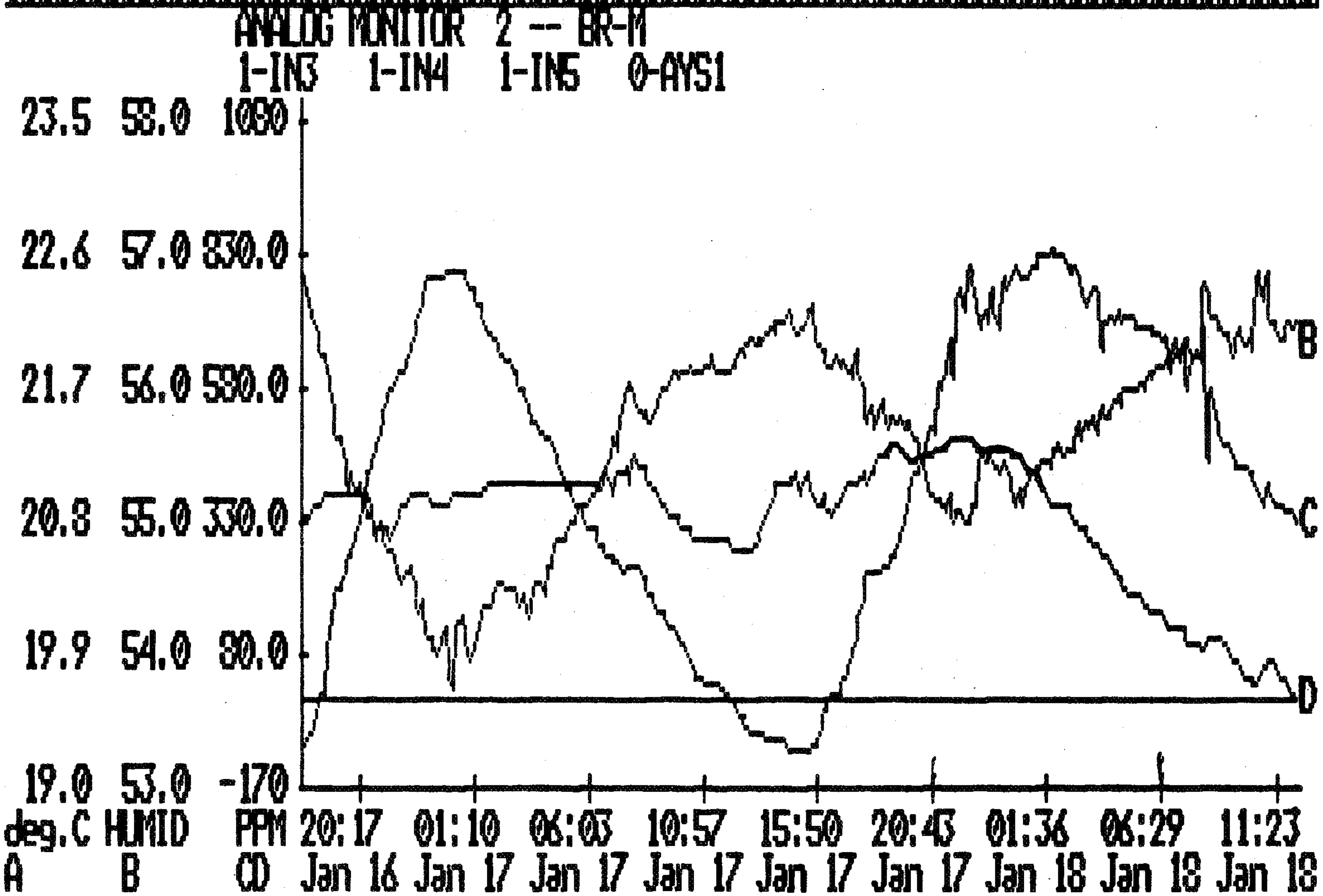


FIRST YEAR DATA

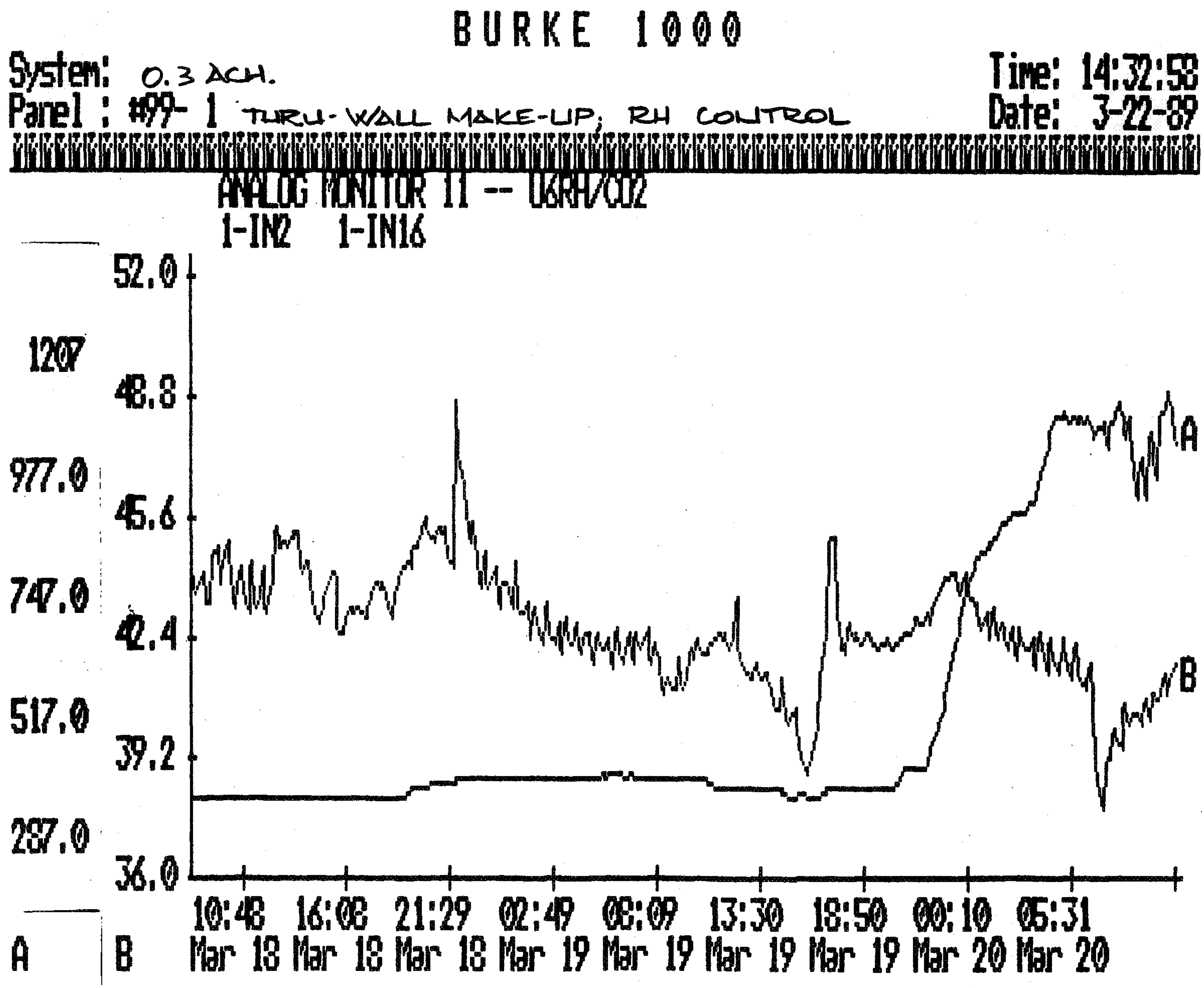
BURKE 1000

System: HECTOR ST 0.15 ACH
Panel : # 1 NEG. PRES. CRW/LSP.

Time: 12:24:19
Date: 1-18-89



FIRST YEAR DATA

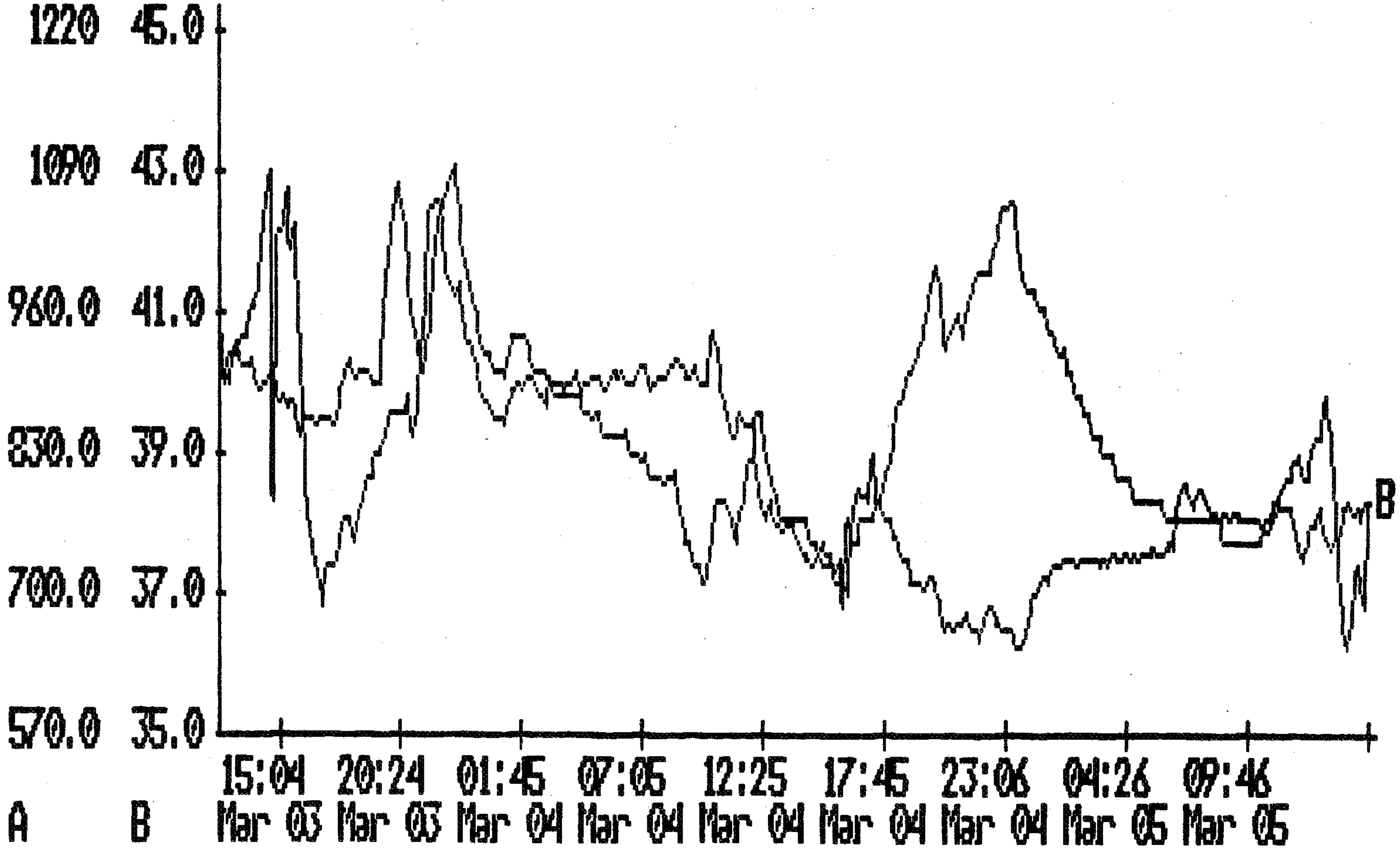


FIRST YEAR DATA

BURKE 1000

System: HRV, LOW VENT. Time: 9:55:14
Panel : #99- 1 Date: 3-21-89

ANALOG MONITOR 5 -- RH/CO2
1-IN2 1-IN6



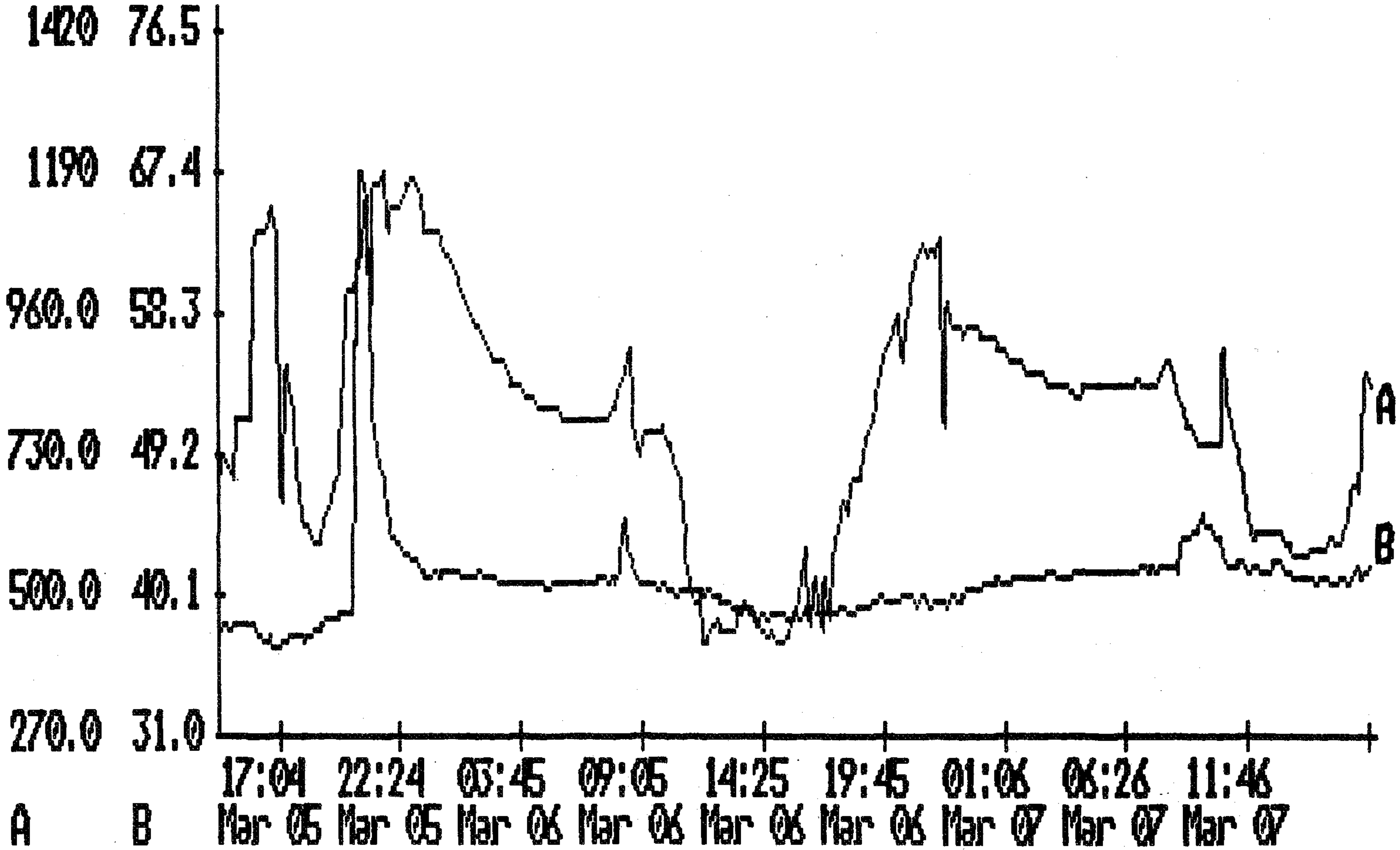
FIRST YEAR DATA

BURKE 1000

System: HRV, LOW VENT.
Panel : #99- 1

Time: 10:03:10
Date: 3-21-89

ANALOG MONITOR 5 -- RH/CO2
1-IN2 1-IN6



FIRST YEAR DATA

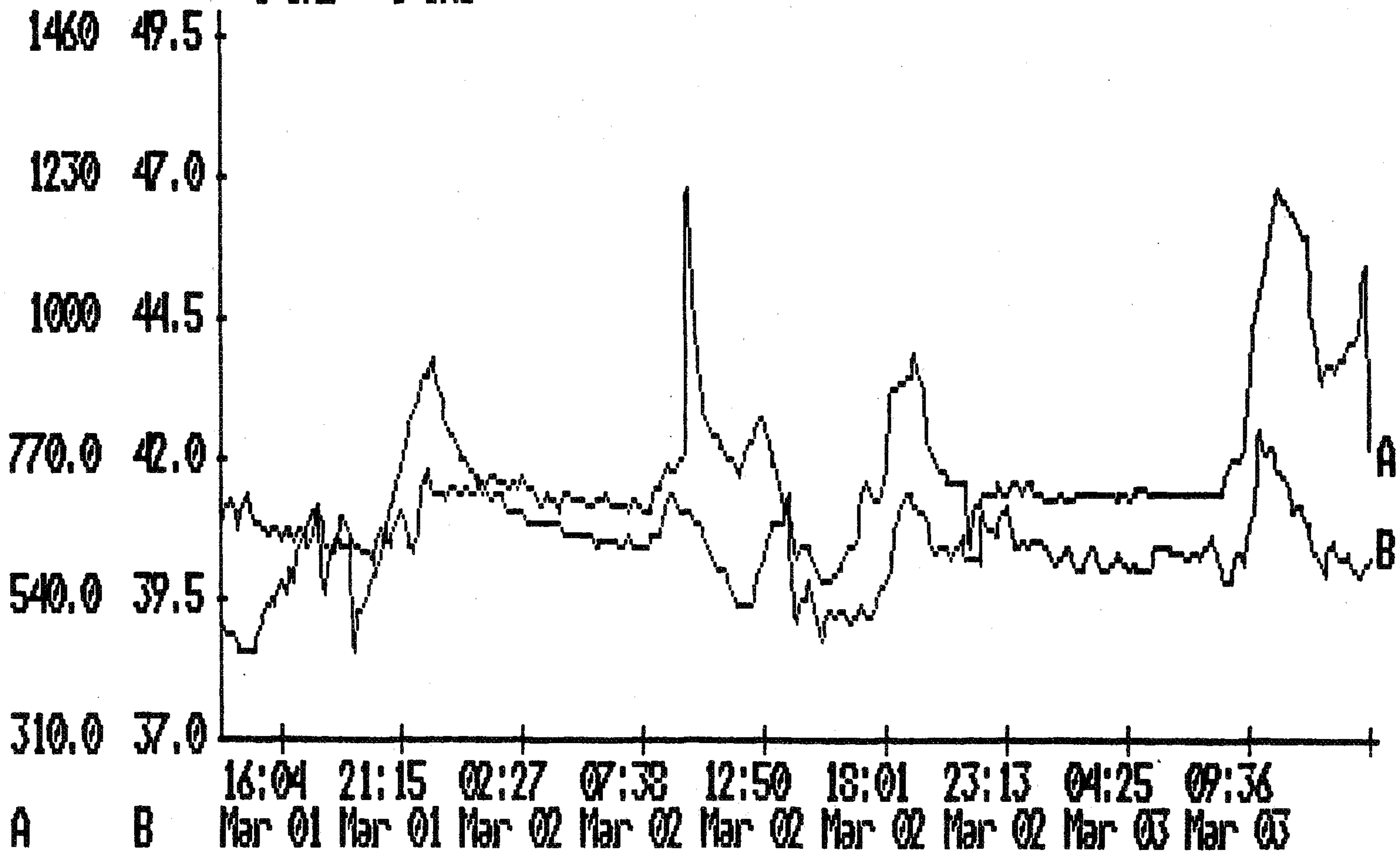
BURKE 1000

System: HRV, LOW VENT — Time: 9:44:34

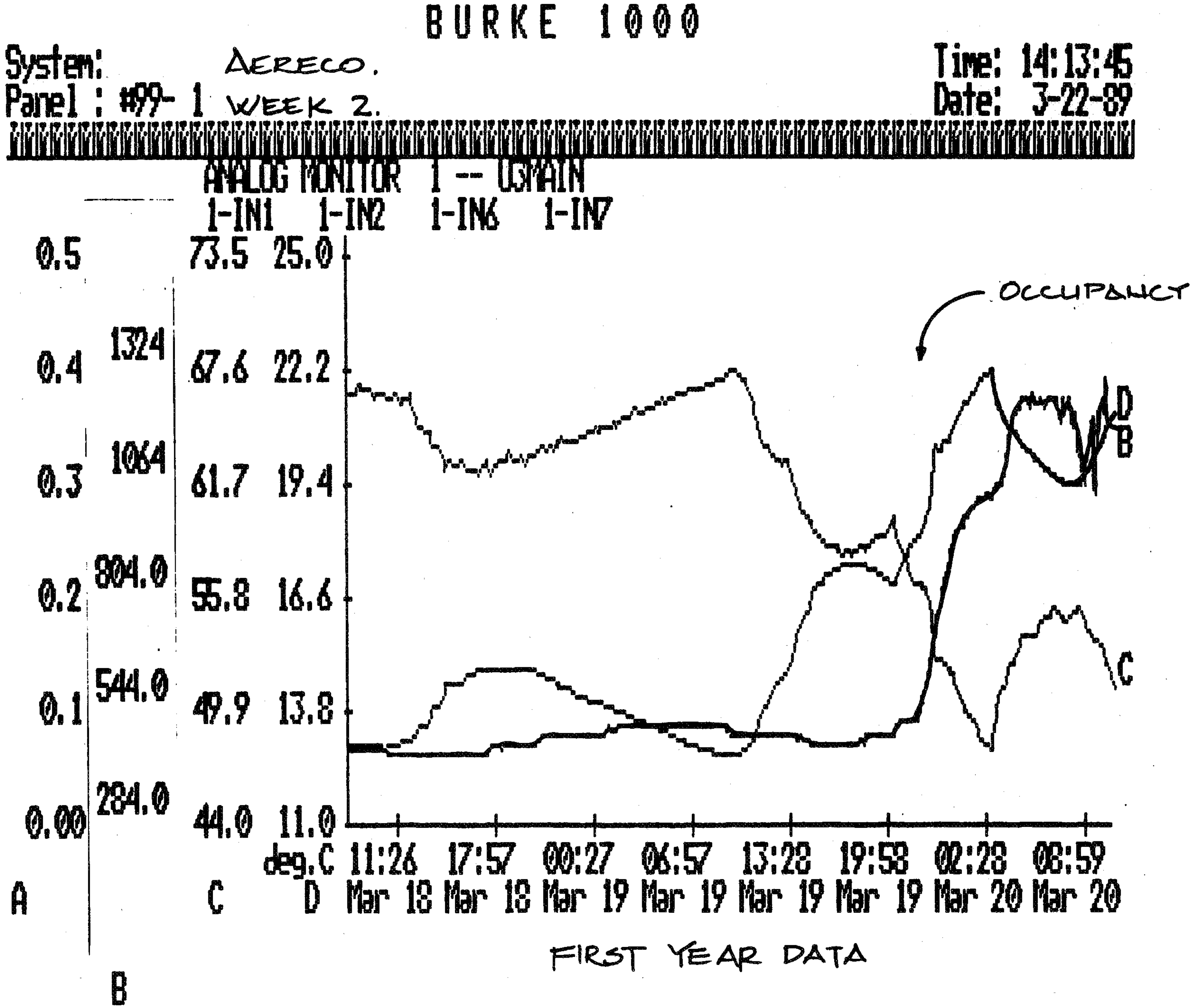
Panel : #99- 1 — Date: 3-21-89

ANALOG MONITOR 5 -- RH/CO2

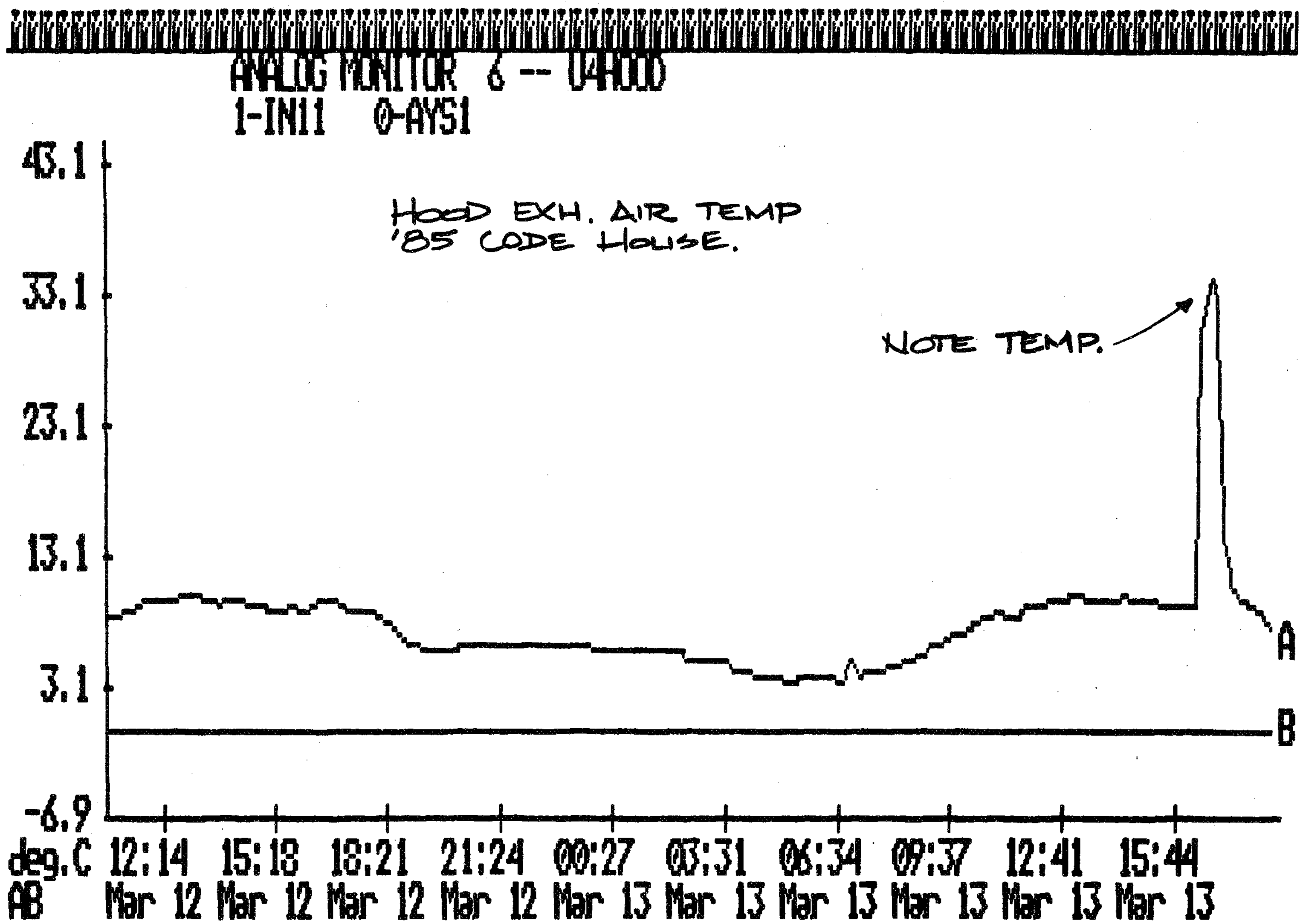
1-IN2 1-IN6



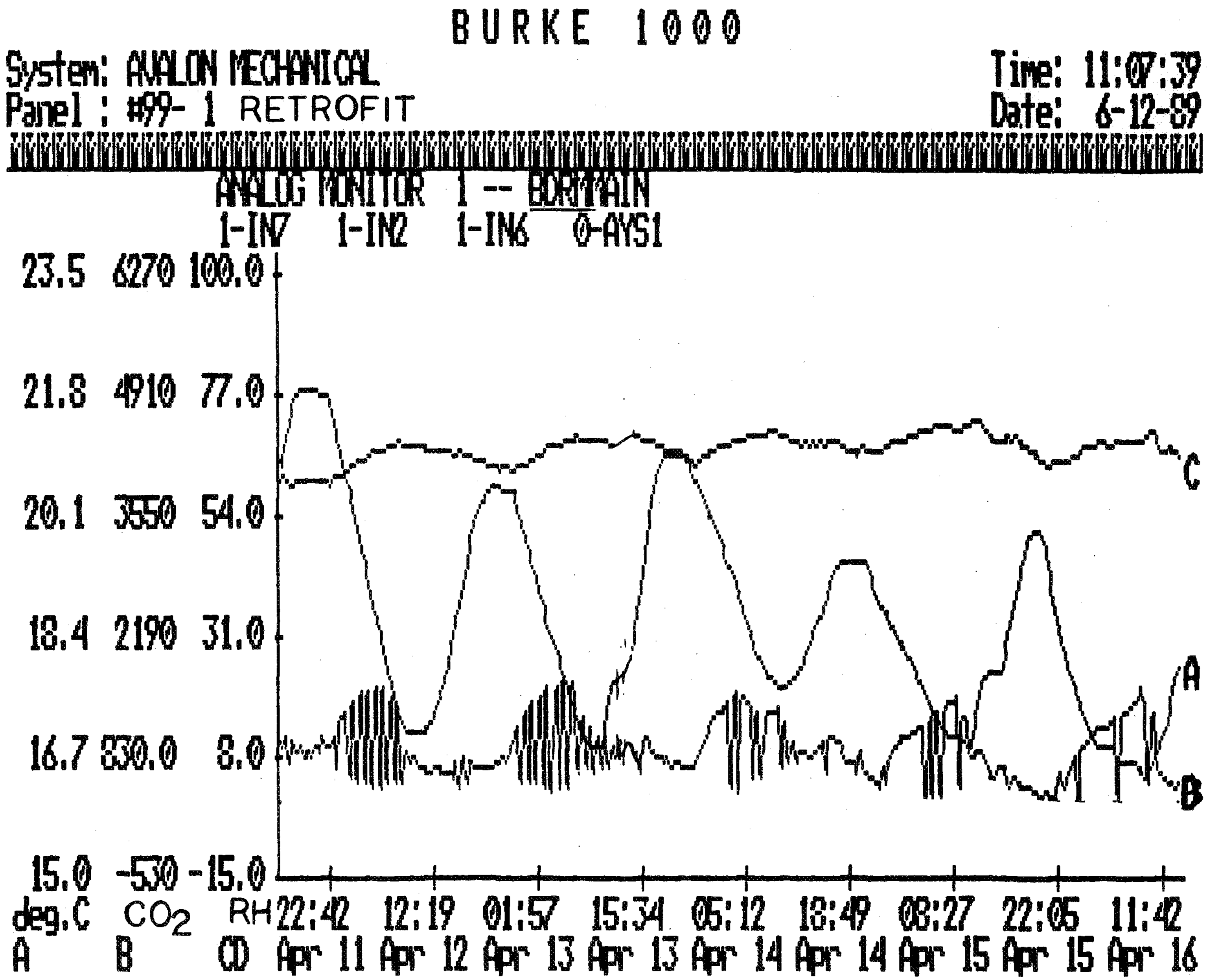
FIRST YEAR DATA



FIRST YEAR DATA



FIRST YEAR DATA

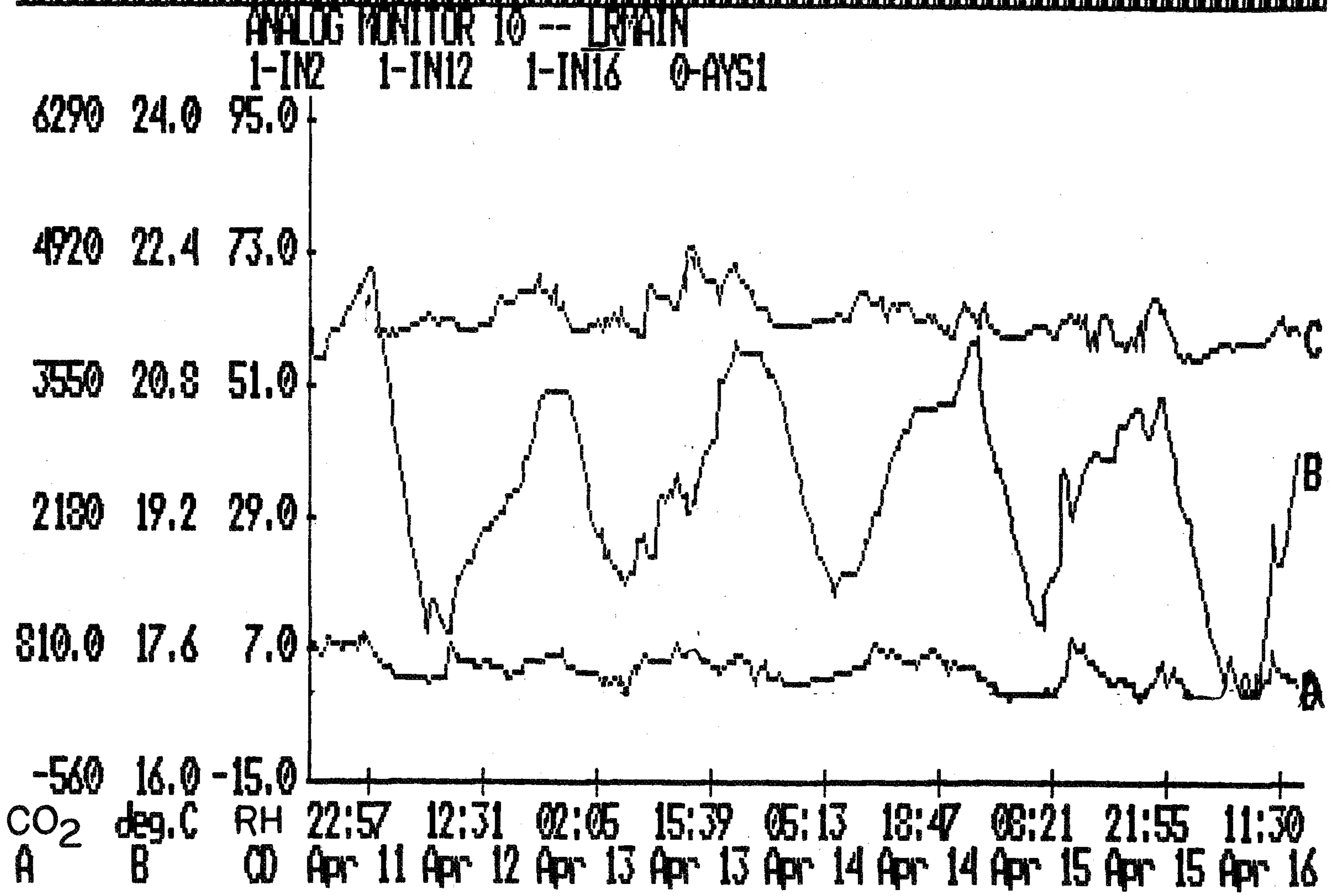


FIRST YEAR DATA

BURKE 1000

System: AVALON MECHANICAL
Panel : #99- 1 RETROFIT

Time: 11:11:09
Date: 6-12-89



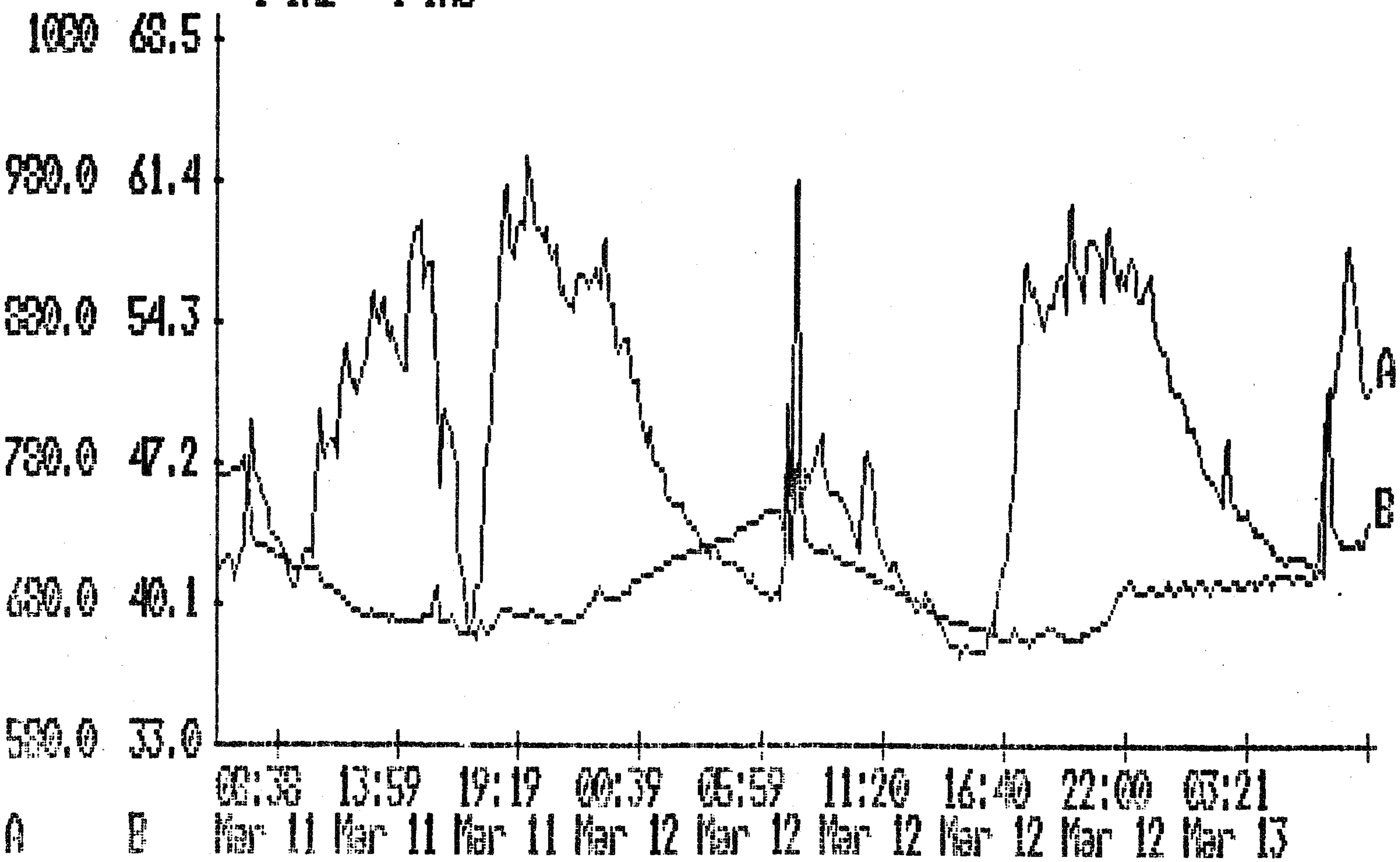
FIRST YEAR DATA

BURKE 1000

System: DEDICATED AIR 0.38 ACH | Time: 10:44:53
Panel : MAIN LIVING AREA SAMPLE | Date: 6-14-90

ANALOG MONITOR 2 -- 03CO2/RH

1-IN2 1-IN6



SECOND YEAR DATA

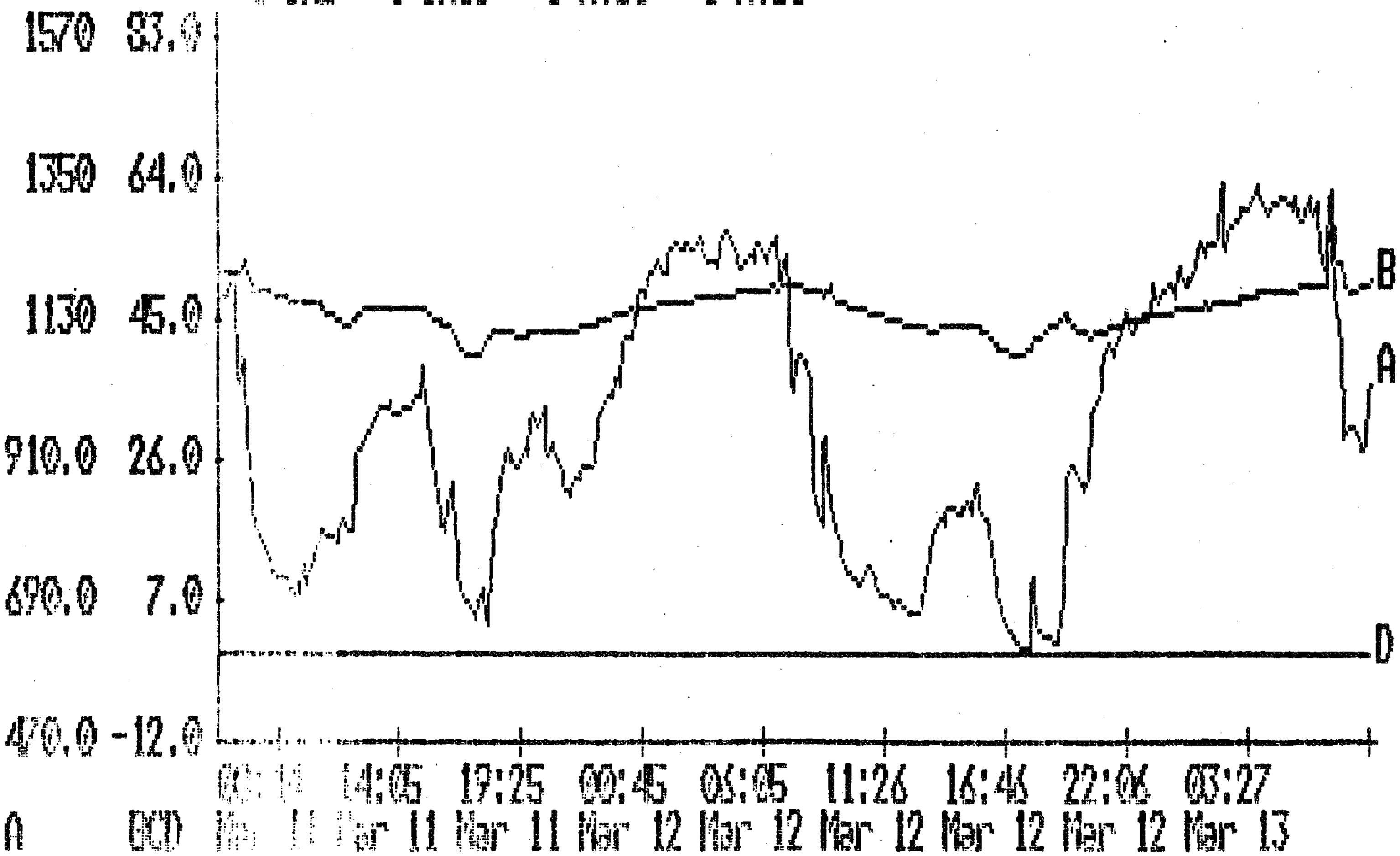
B U R K E 1 0 0 0

System: DEDICATED AIR 0.36 ACH
Panel : BEDROOM SAMPLE

Time: 10:56:43
Date: 6-14-90

ANALOG MONITOR 9 -- USCO2/RH

1-IN2 1-IN13 0-AYS1 0-AYS1



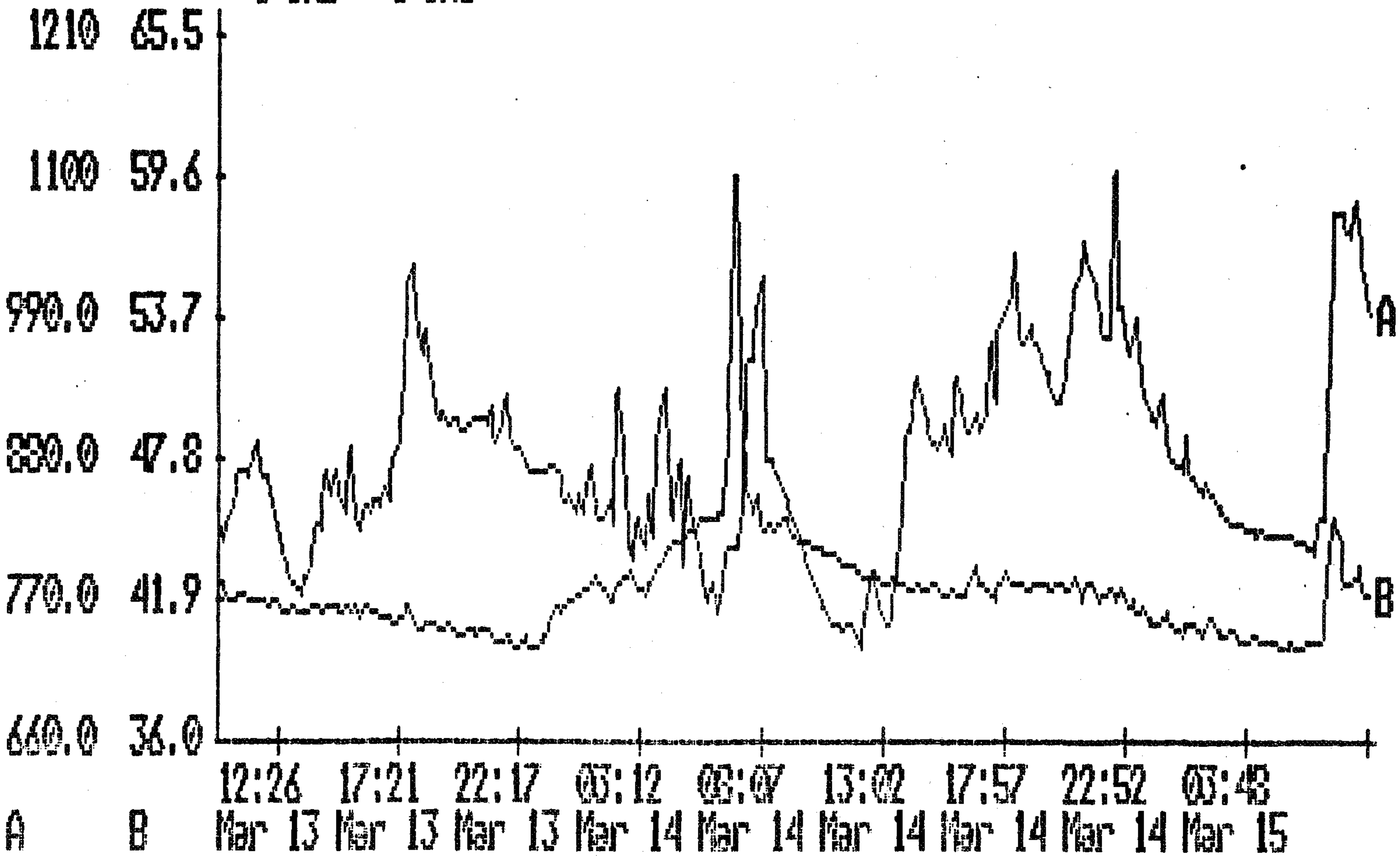
SECOND YEAR DATA

BURKE 1000

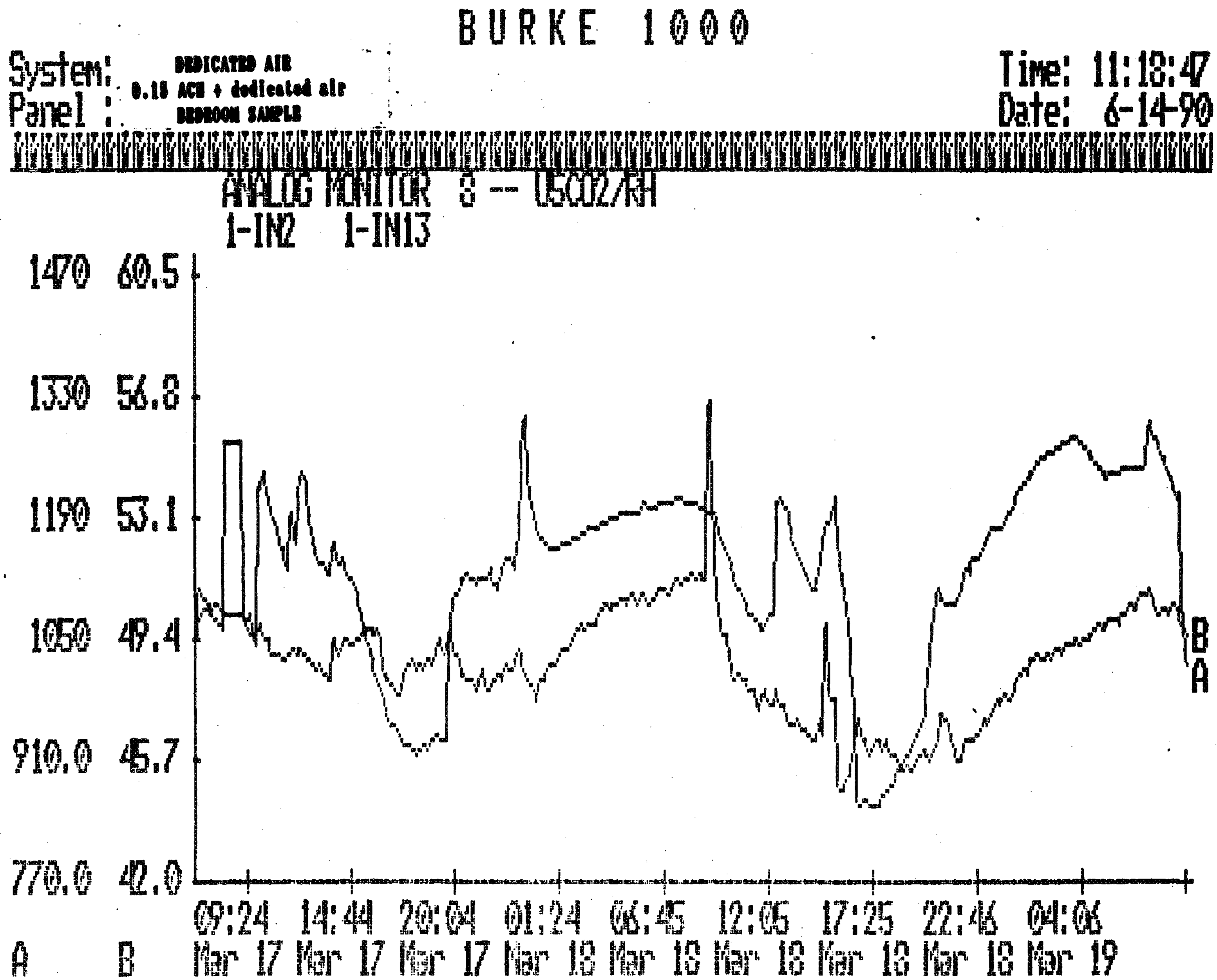
System: DEDICATED AIR
0.15 ACH
Panel : MAIN LIVING AREA SAMPLE

Time: 11:01:42
Date: 6-14-90

ANALOG MONITOR 2 -- LSCO2/RH
1-IN2 1-IN6



SECOND YEAR DATA



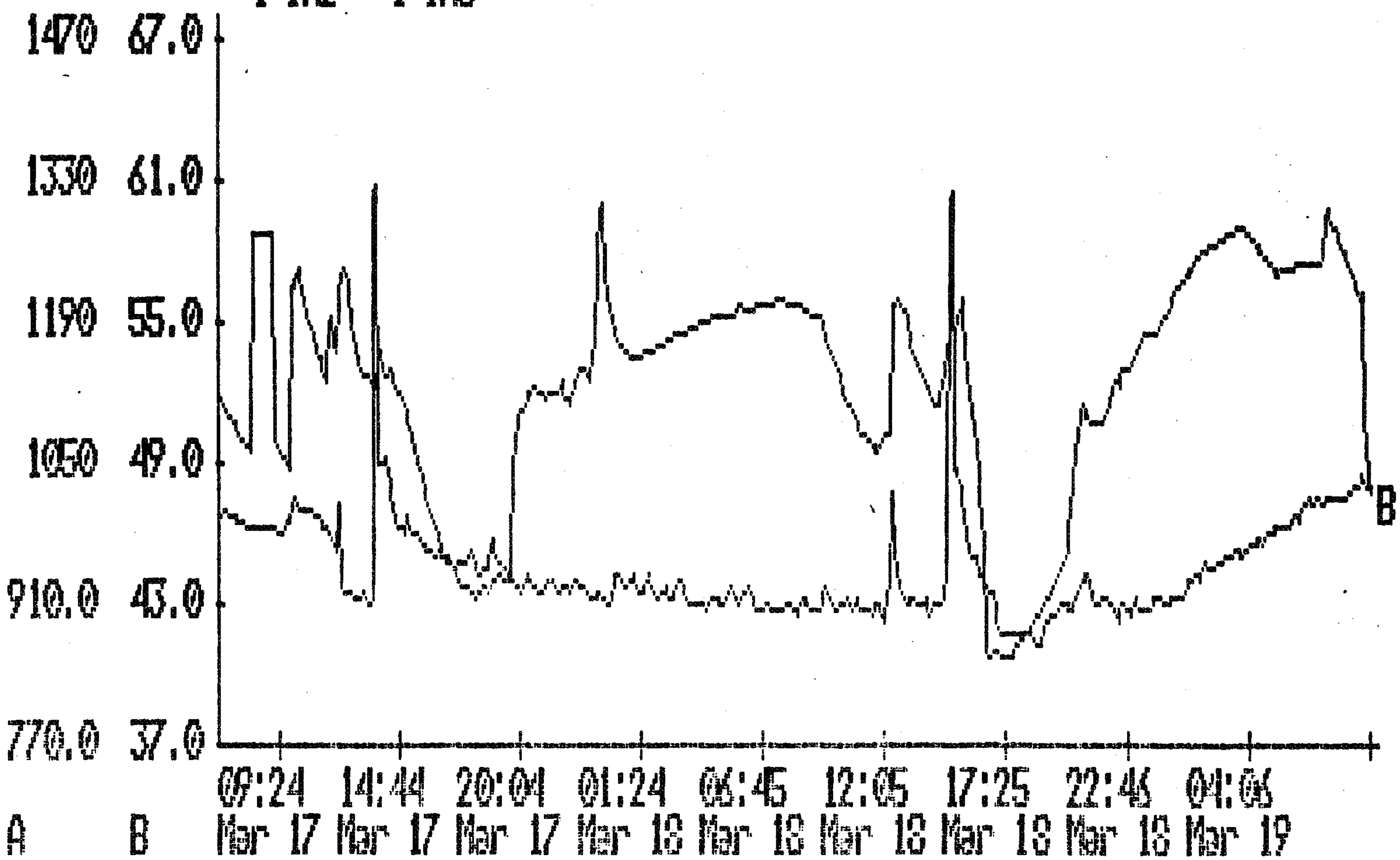
SECOND YEAR DATA

BURKE 1000

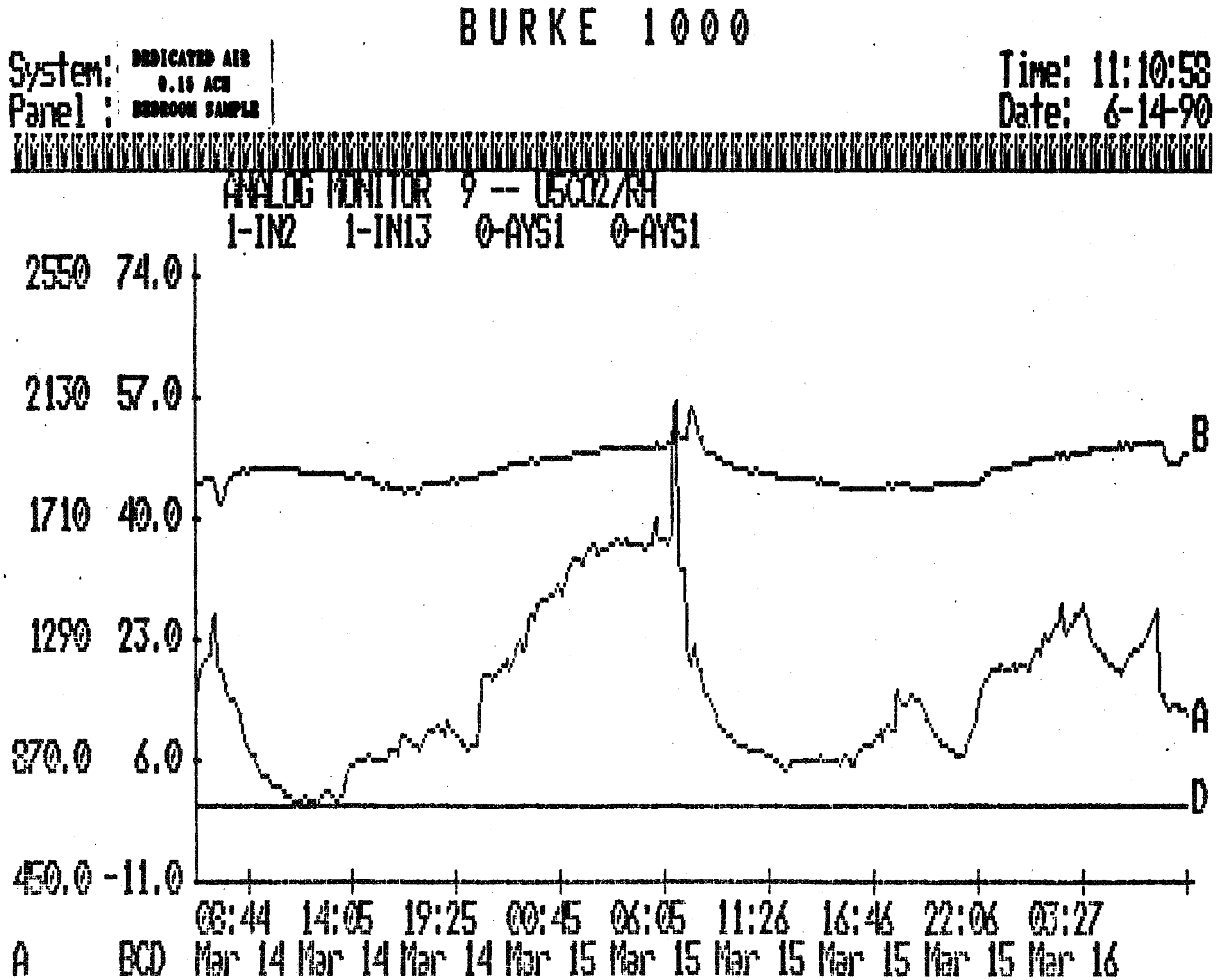
System: DEDICATED AIR
0.15 ACH + dedicated air
Panel : MAIN LIVING AREA SAMPLE

Time: 11:15:04
Date: 6-14-90

ANALOG MONITOR 2 -- UGCO2/RH
1-IN2 1-IN6



SECOND YEAR DATA

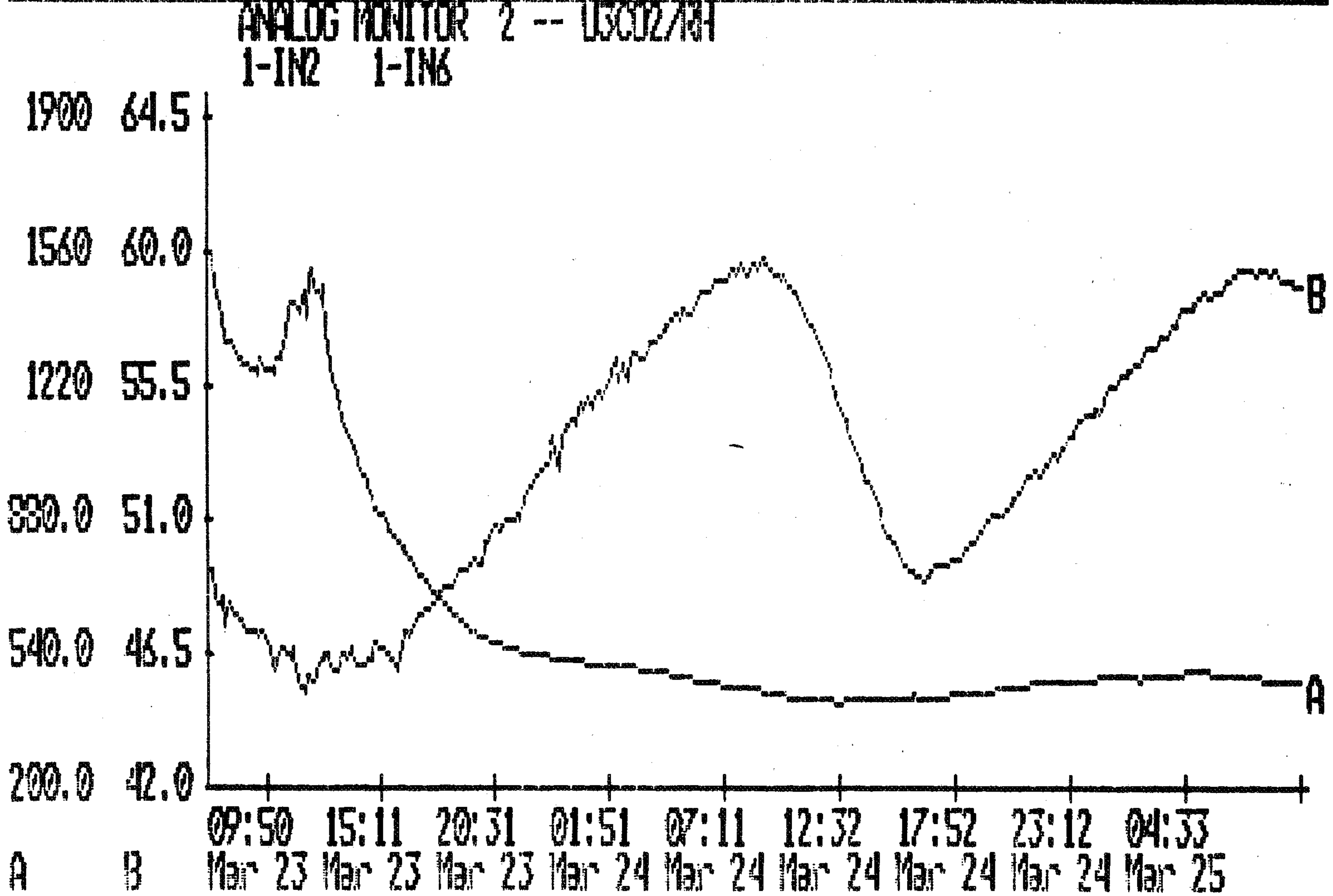


SECOND YEAR DATA.

BURKE 1000

System: UNIT 3 - AERECO
0.18 ACH self-adjusting
Panel : MAIN LIVING AREA SAMPLE

Time: 3:53:47
Date: 6-13-90

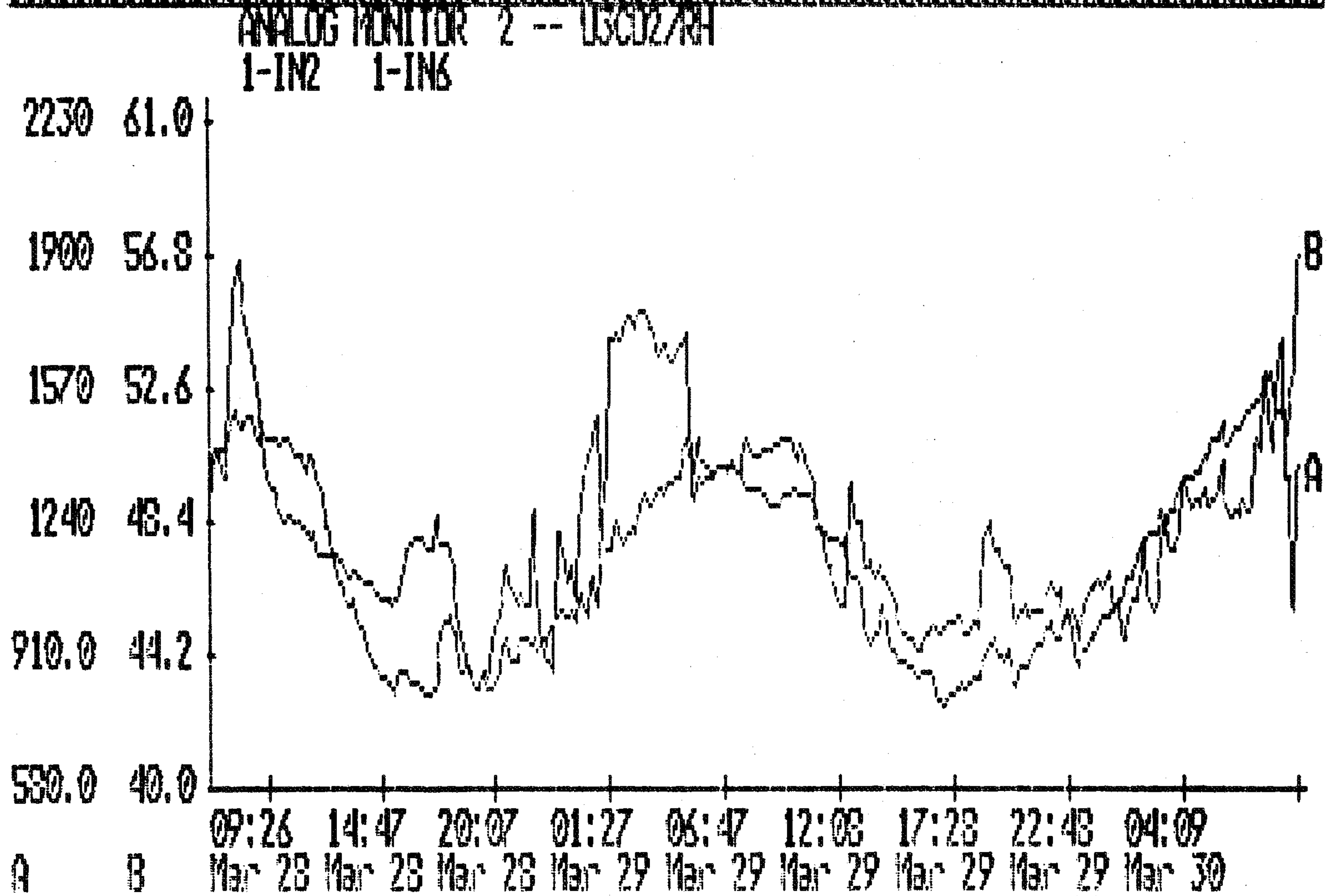


SECOND YEAR DATA

BURKE 1000

System: UNIT 3 - AERECO
0.18 ACH self-adjusting
Panel : BEDROOM SAMPLE

Time: 0:32:38
Date: 1-01-80



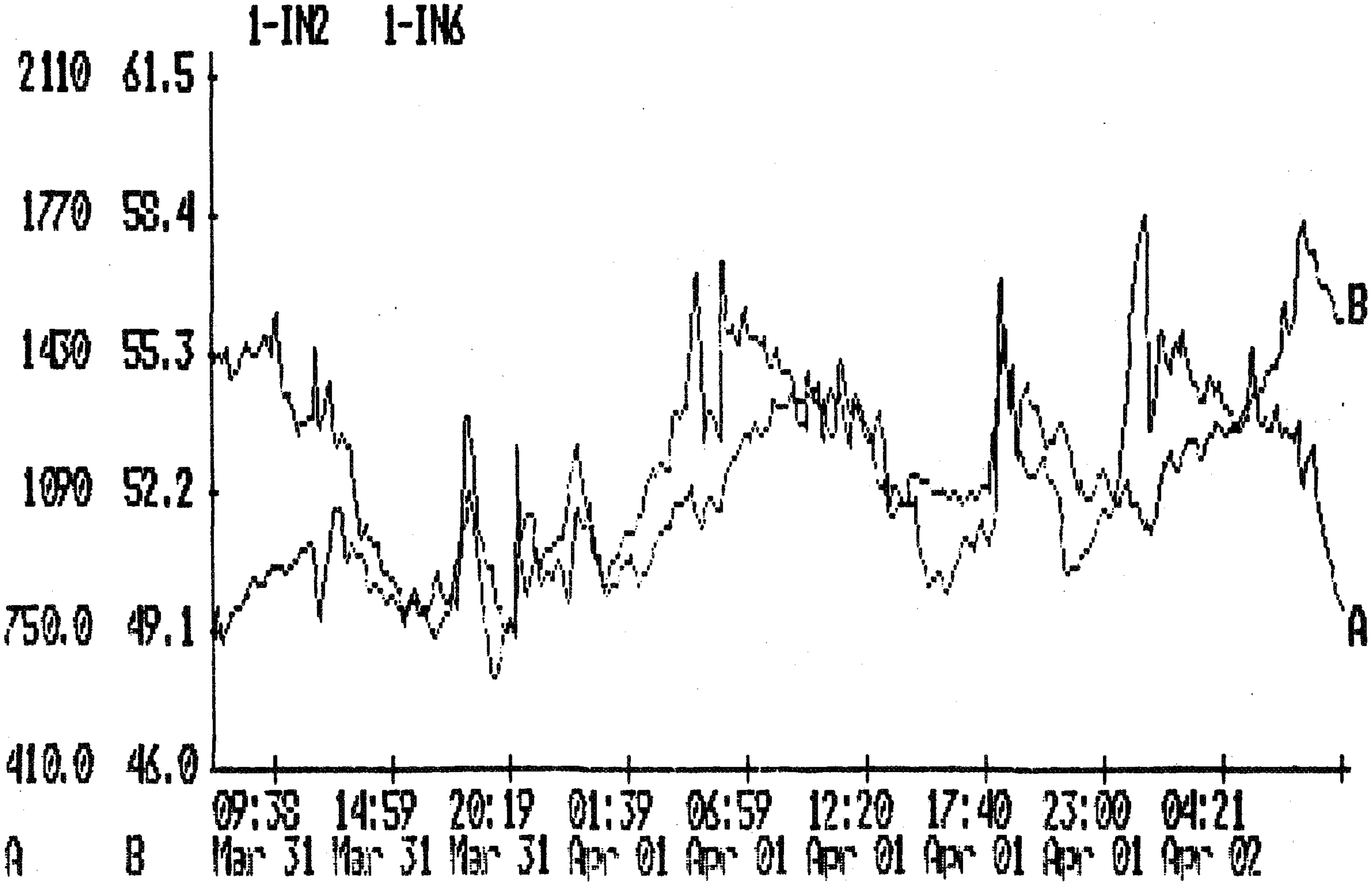
SECOND YEAR DATA

BURKE 1000

System: UNIT 3 - AERECO
0.10 ACH self-adjusting
Panel : BEDROOM SAMPLE

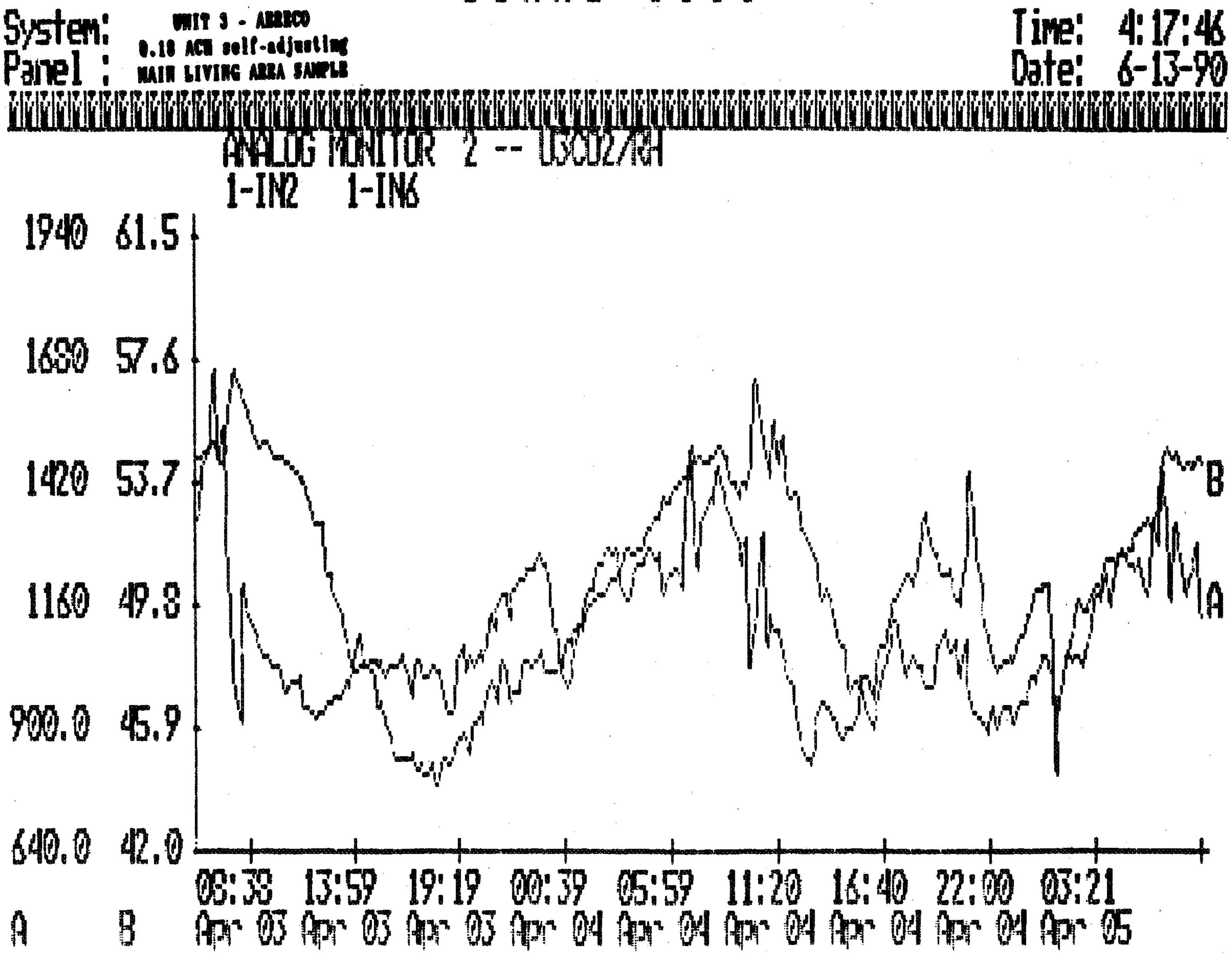
Time: 0:07:21
Date: 1-01-80

ANALOG MONITOR 2 -- U3CO2/RH



SECOND YEAR DATA

BURKE 1000

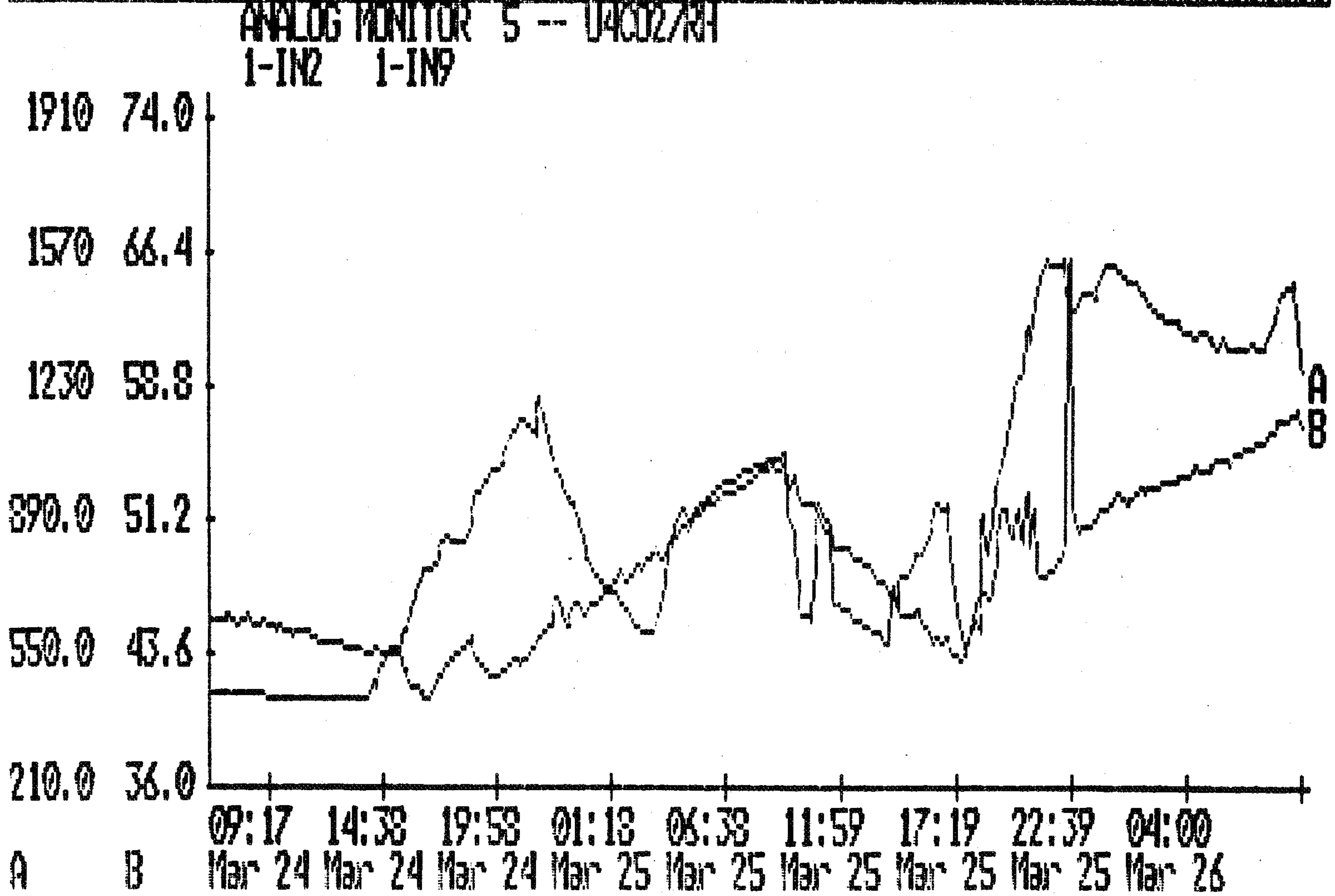


SECOND YEAR DATA

BURKE 1000

System: UNIT 4 - B.C. CODE HOUSE
0.15 ACH continuous
Panel : MAIN LIVING AREA SAMPLE

Time: 4:03:22
Date: 6-13-90



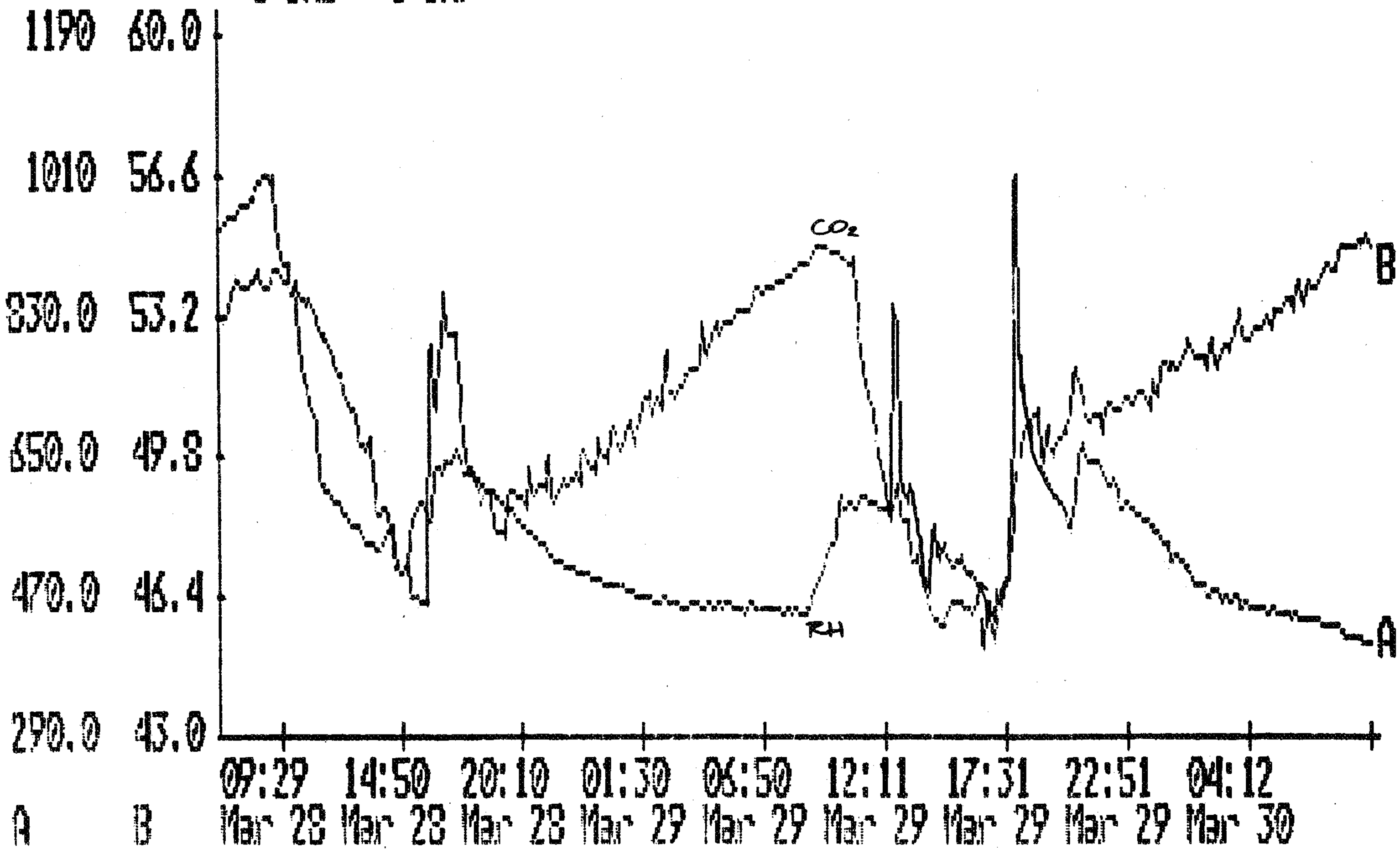
SECOND YEAR DATA

BURKE 1000

System: UNIT 4 - B.C. CODE HOUSE
0.15 ACH continuous
Panel : BEDROOM SAMPLE

Time: 0:37:22
Date: 1-01-80

ANALOG MONITOR 5 -- U4CO2/RH
1-IN2 1-IN9



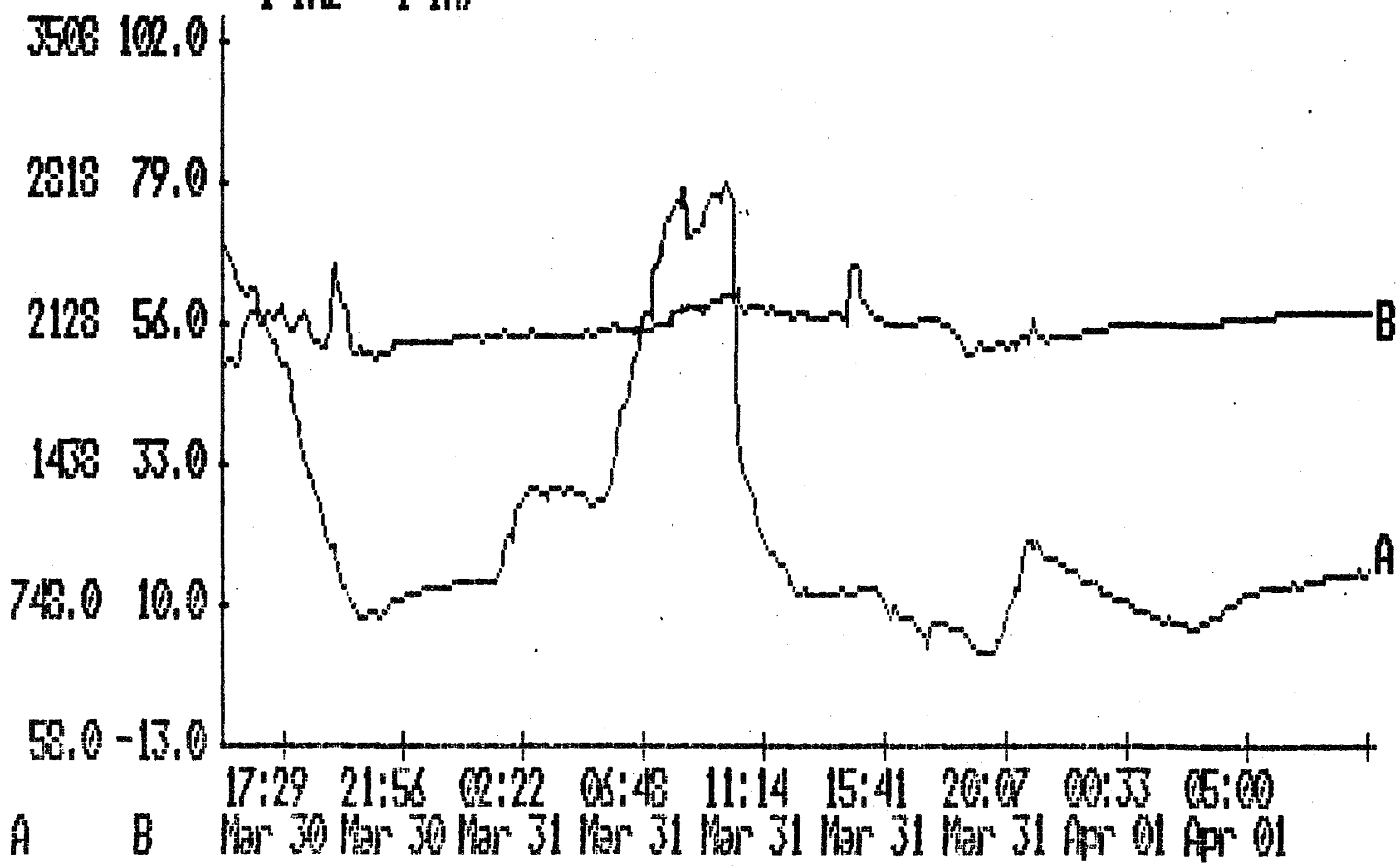
SECOND YEAR DATA

BURKE 1000

System: UNIT 4 - B.C. CODE HOUSE
0.3 ACH dehumidistat
Panel : BEDROOM SAMPLE

Time: 11:24:12
Date: 6-14-90

ANALOG MONITOR 5 -- U4CO2/RH
1-IN2 1-IN9



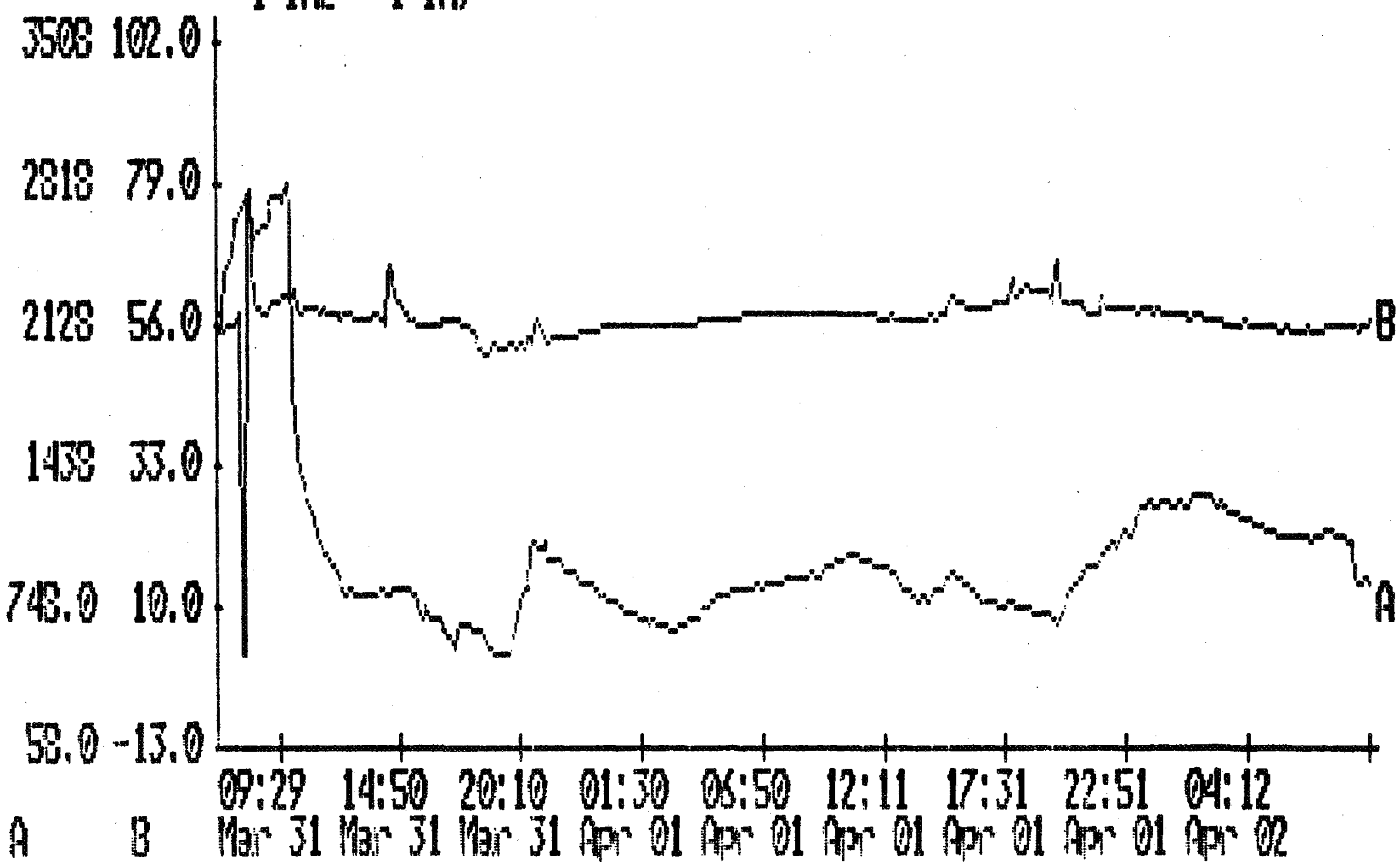
SECOND YEAR DATA.

BURKE 1000

System: UNIT 4 - B.C. CODE HOUSE
0.3 ACH dehumidistat
Panel : BEDROOM SAMPLE

Time: 0:11:35
Date: 1-01-80

ANALOG MONITOR 5 -- U4CO2/RH
1-IN2 1-IN9



SECOND YEAR DATA

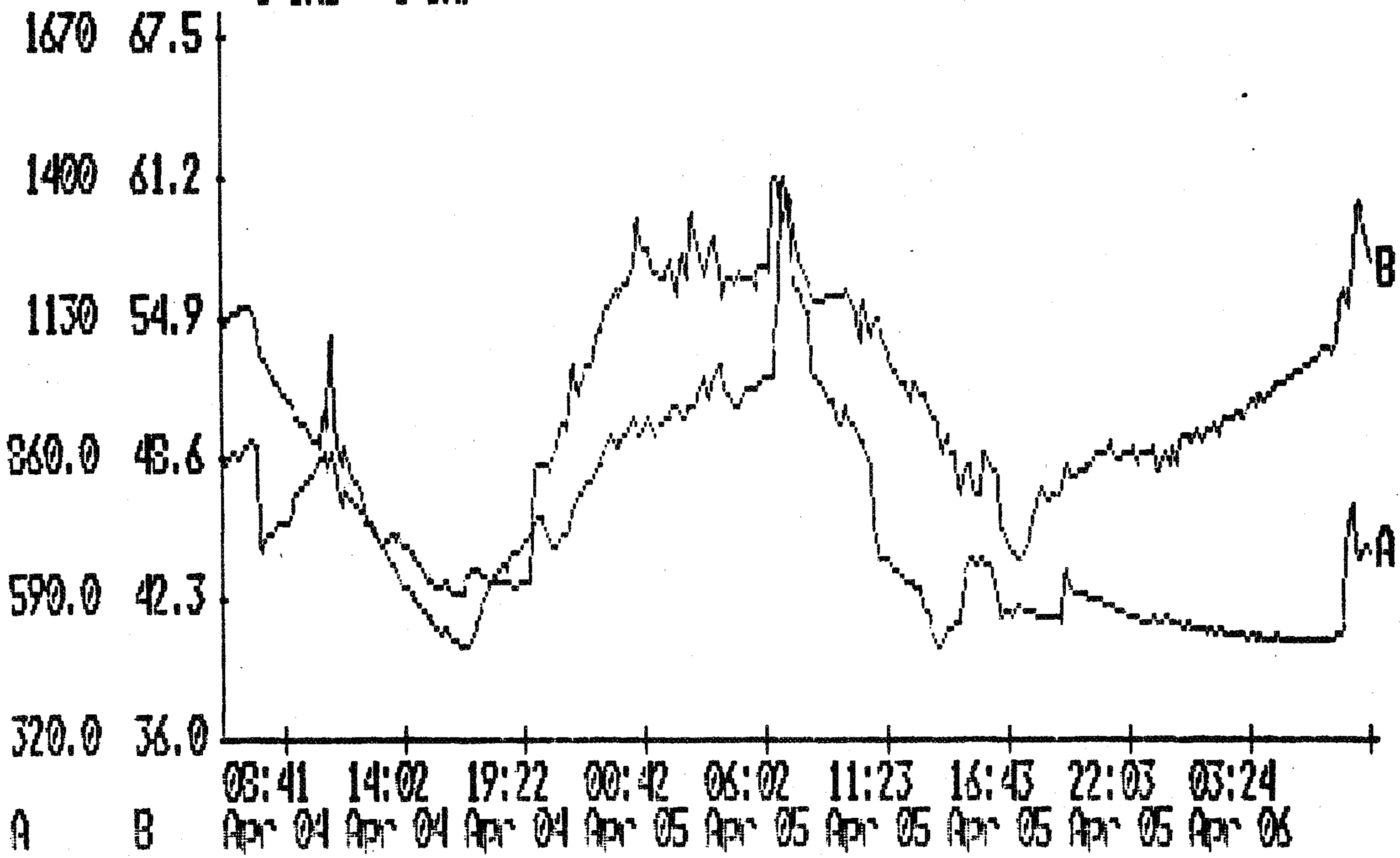
BURKE 1000

System: UNIT 4 - B.C. CODE HOUSE
0.3 ACH dehumidistat
Panel : MAIN LIVING AREA SAMPLE

Time: 4:26:02
Date: 6-13-90

ANALOG MONITOR 5 -- U4CO2/RH

1-IN2 1-IN9

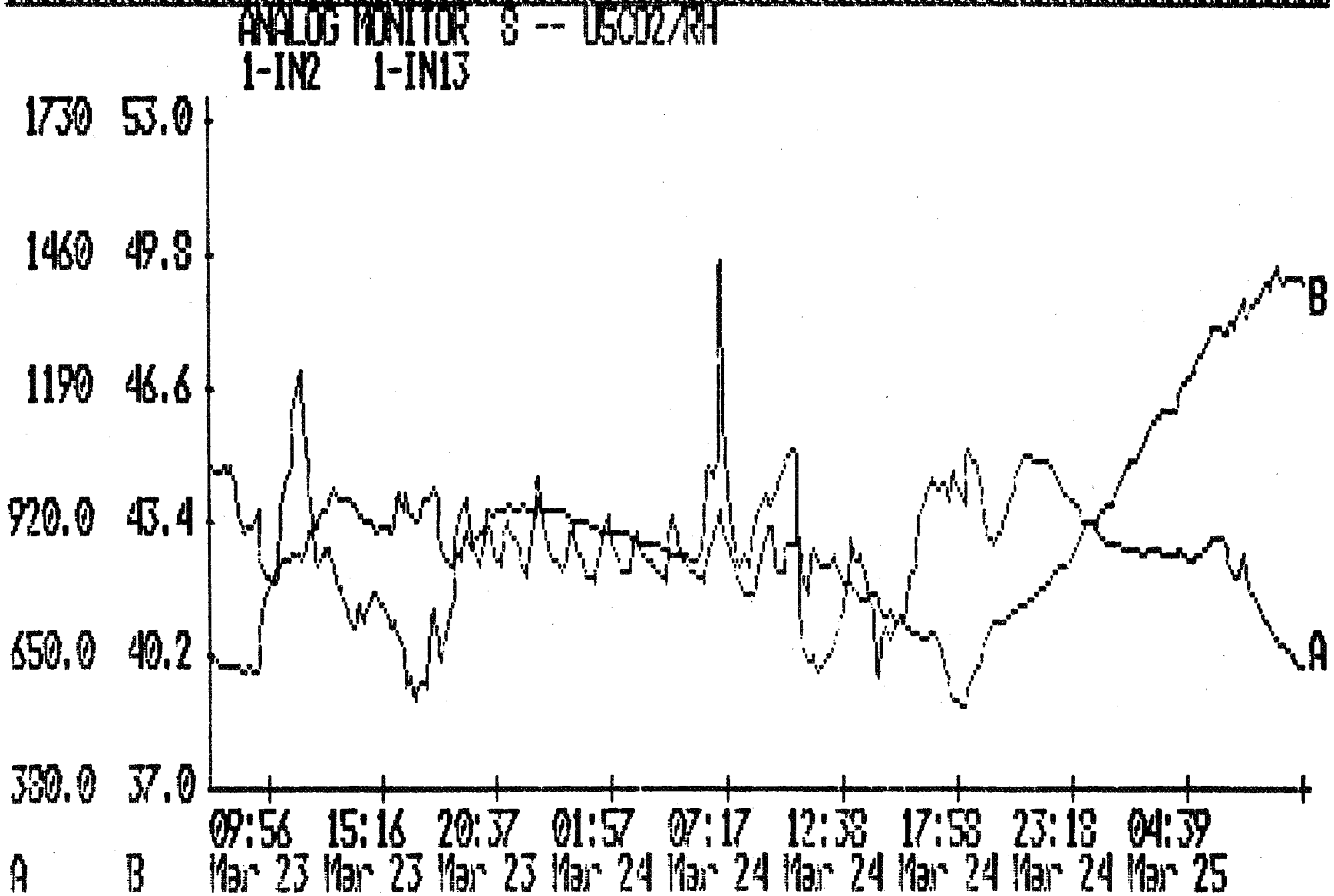


SECOND YEAR DATA

BURKE 1000

System: UNIT 5 - WALL PIPE
0.3 ACH dehumidistat
Panel : MAIN LIVING AREA SAMPLE

Time: 3:58:04
Date: 6-13-90



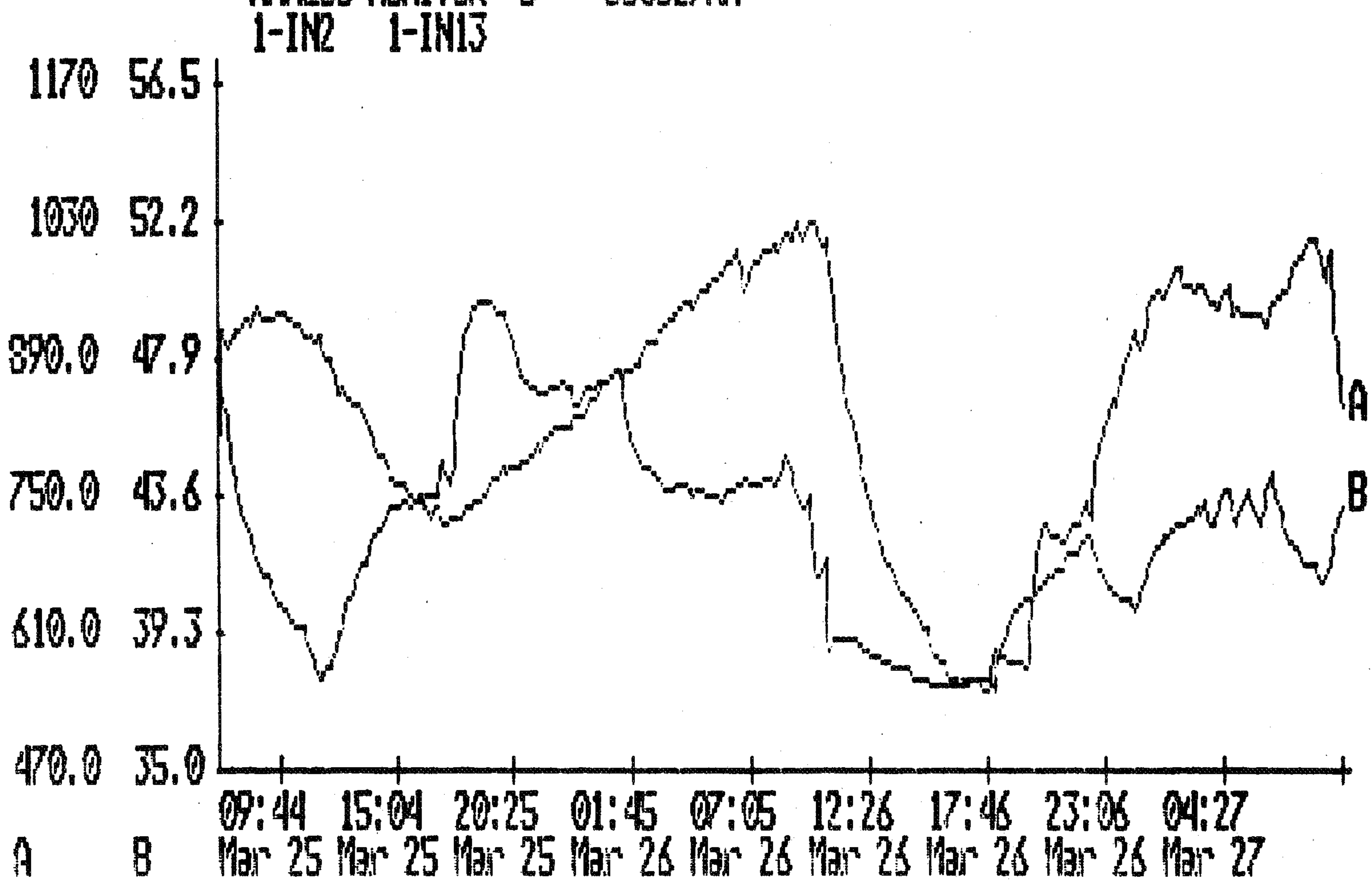
SECOND YEAR DATA

BURKE 1000

System: UNIT 8 - WALL PIPE
0.3 ACH dehumidistat
Panel : MAIN LIVING AREA SAMPLE

Time: 4:08:28
Date: 6-13-90

ANALOG MONITOR 8 -- U8CO2/RH



SECOND YEAR DATA

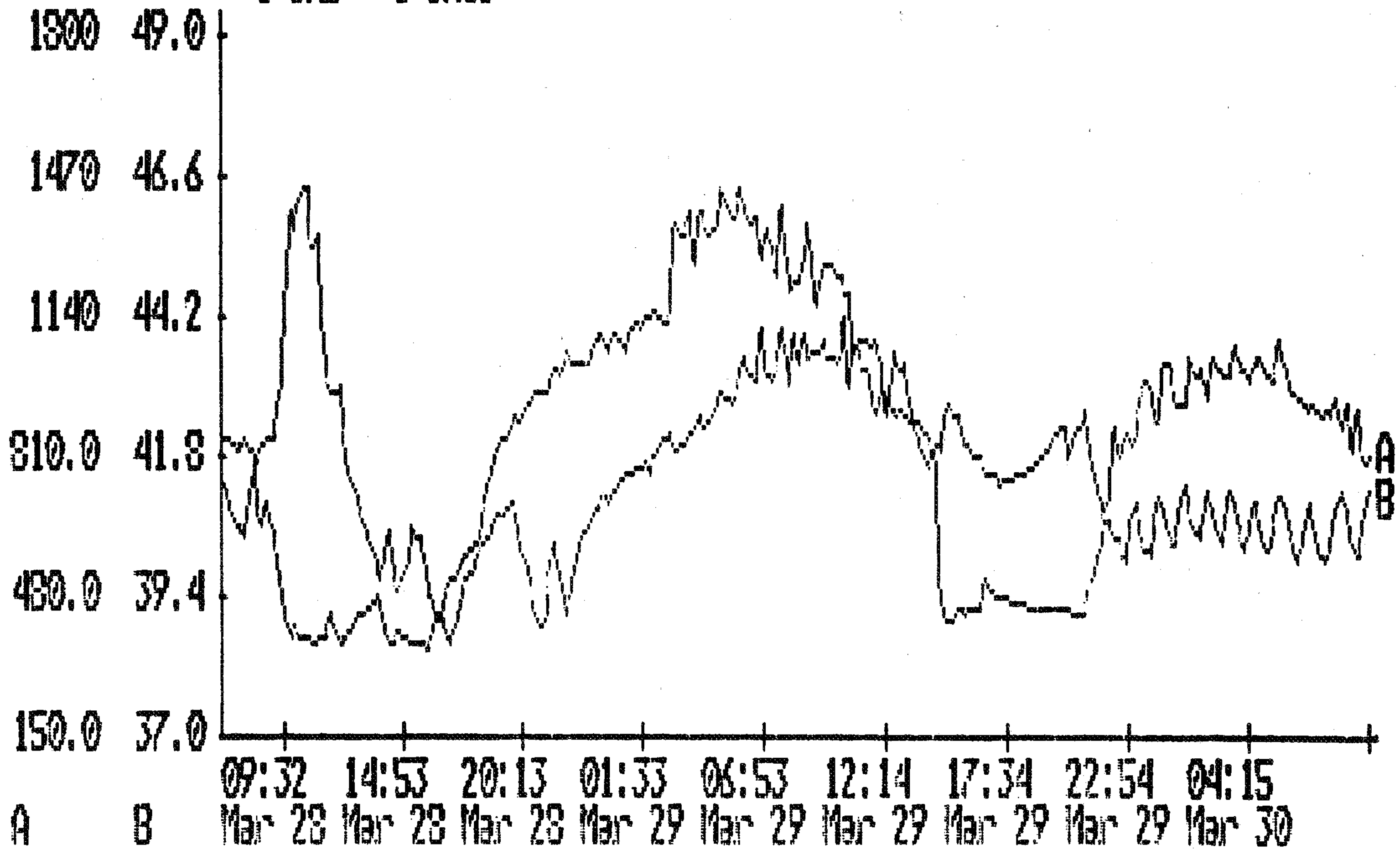
BURKE 1000

System: UNIT 8 - WALL PIPE
0.3 ACH dehumidistat

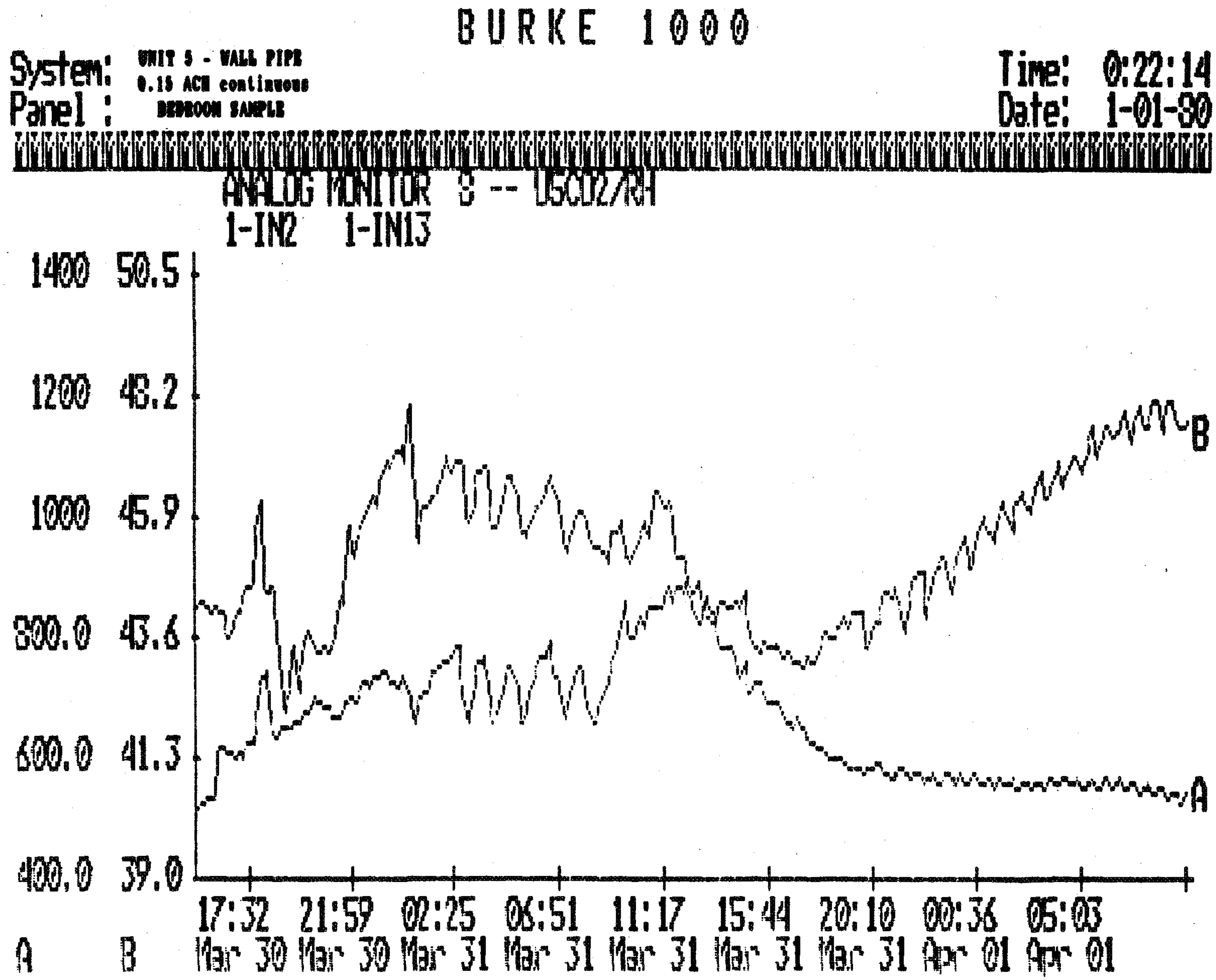
Panel : BEDROOM SAMPLE

Time: 0:41:52
Date: 1-01-80

ANALOG MONITOR 8 -- U5CO2/RH
1-IN2 1-IN13



SECOND YEAR DATA



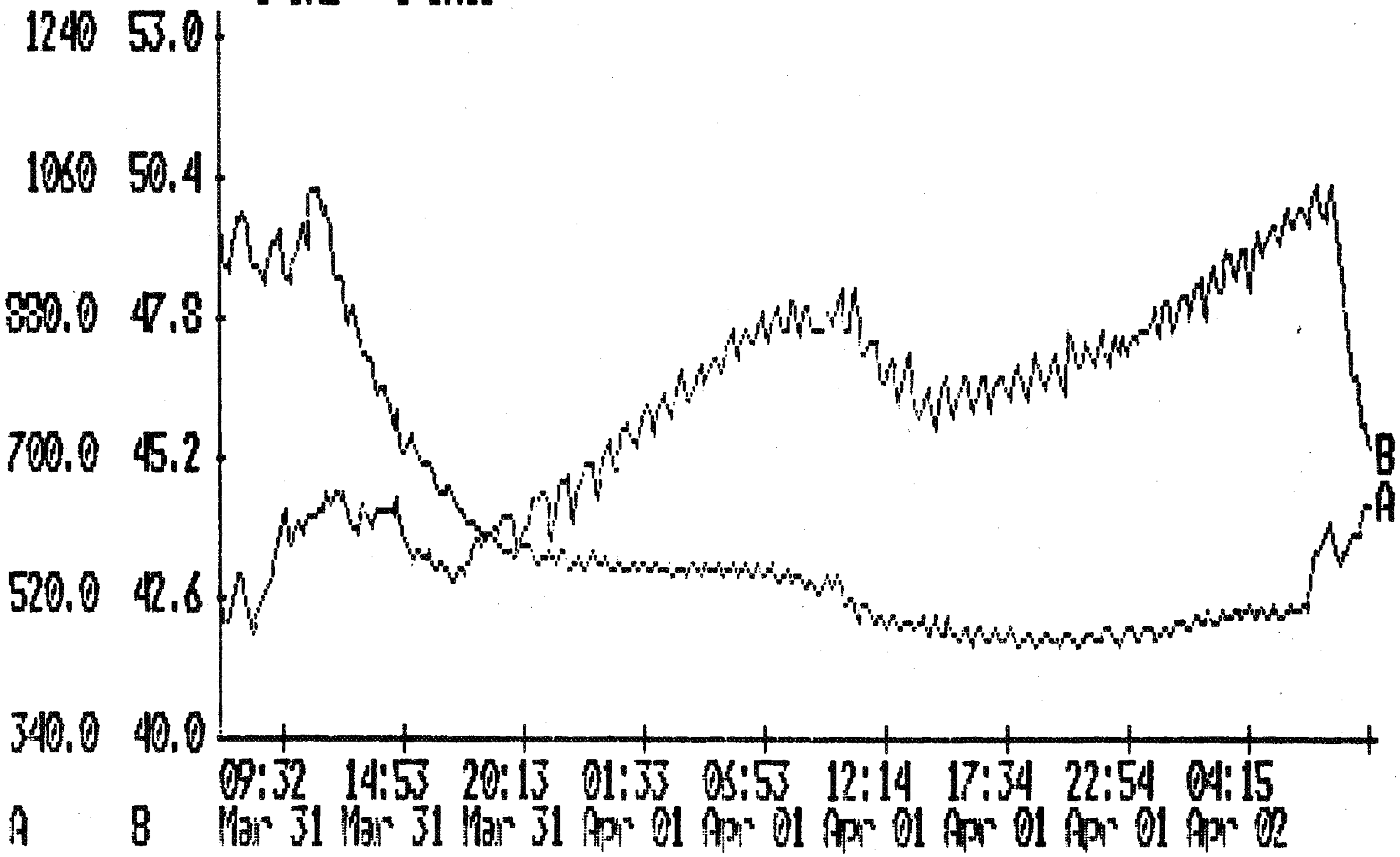
SECOND YEAR DATA

BURKE 1000

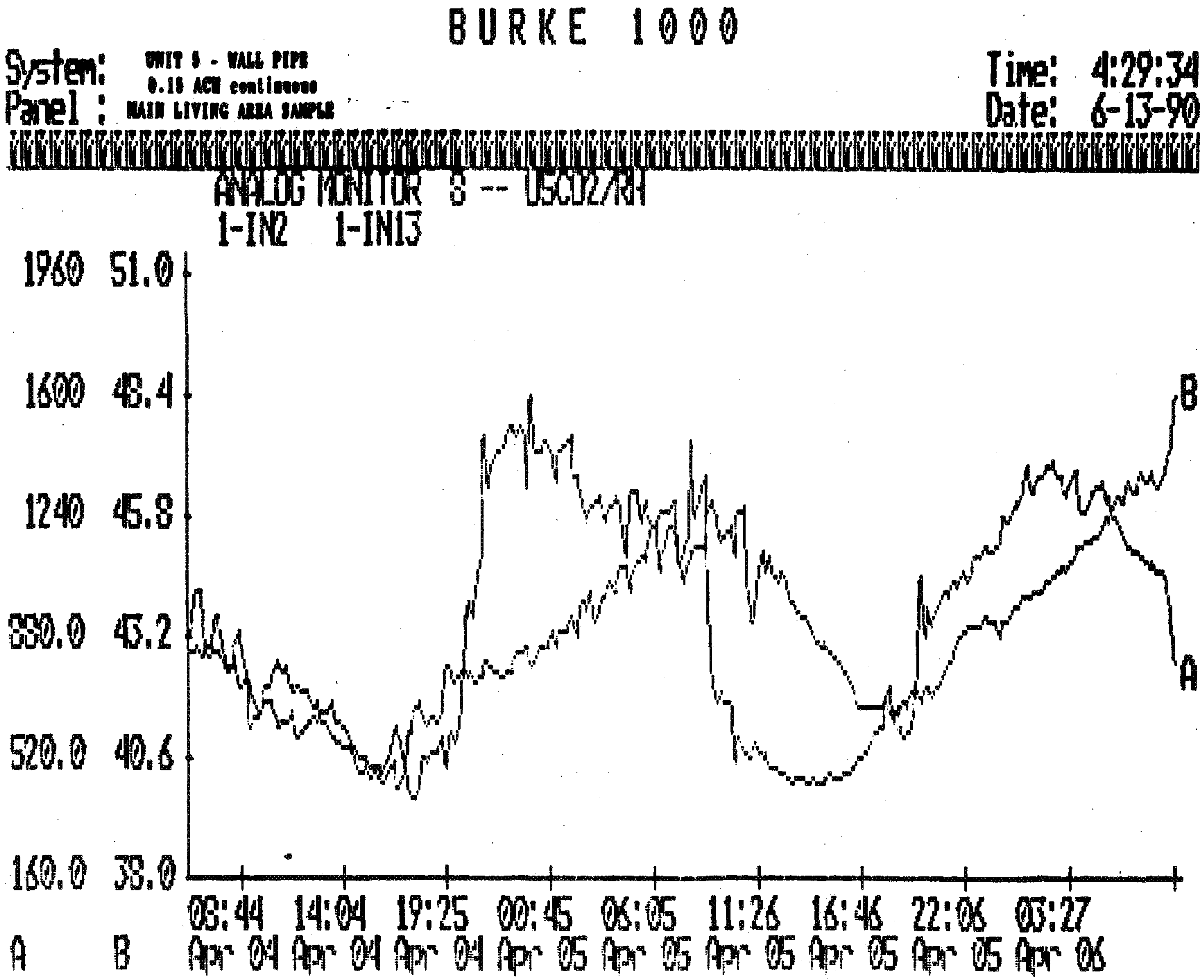
System: UNIT 8 - WALL PIPE
0.18 ACH continuous
Panel : BEDROOM SAMPLE

Time: 0:17:13
Date: 1-01-80

ANALOG MONITOR 8 -- USCO2/RH
1-IN2 1-IN13



SECOND YEAR DATA

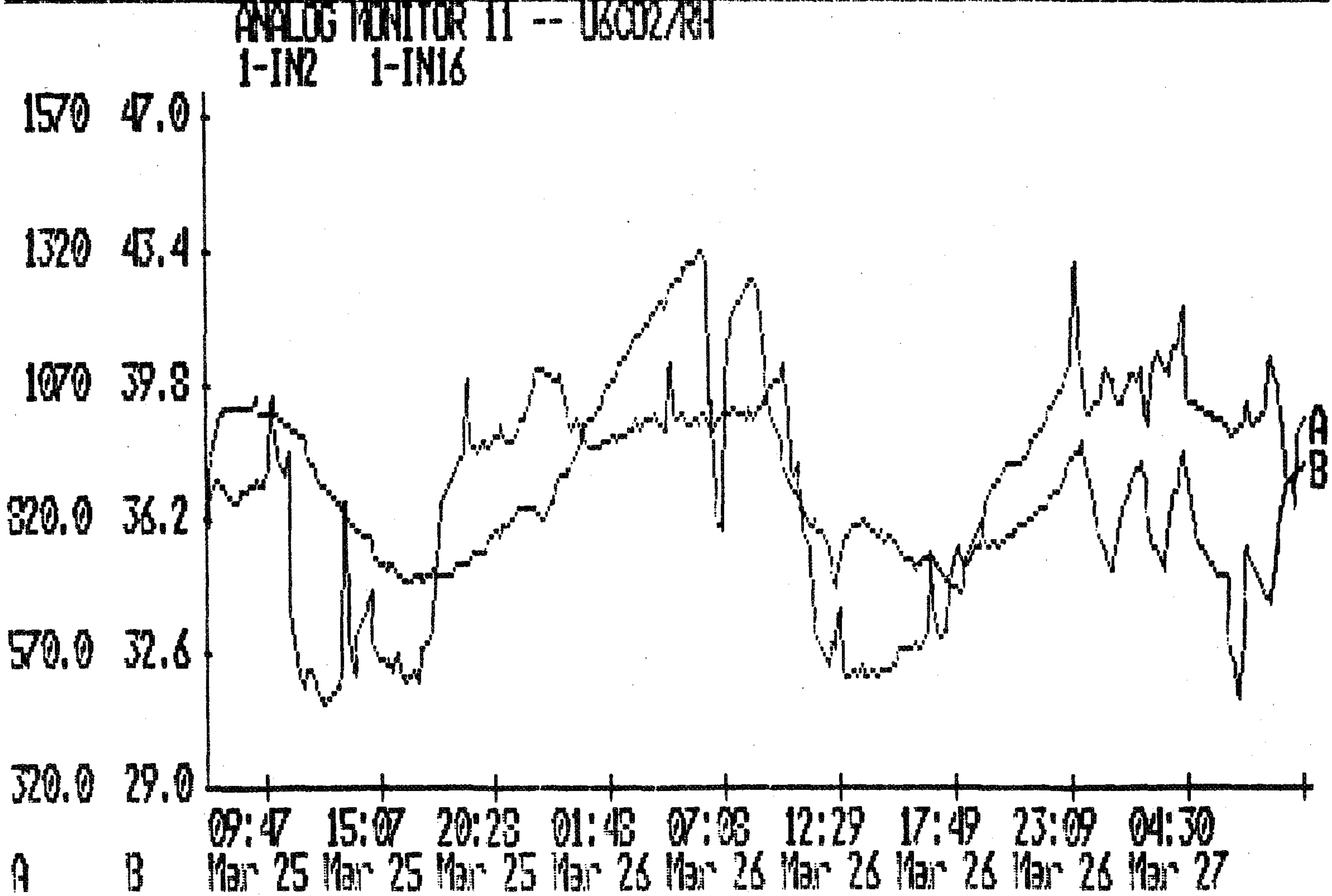


SECOND YEAR DATA

BURKE 1000

System: UNIT 6 - WALL PIPE
0.15 ACH continuous
Panel : MAIN LIVING AREA SAMPLE

Time: 4:13:06
Date: 6-13-90



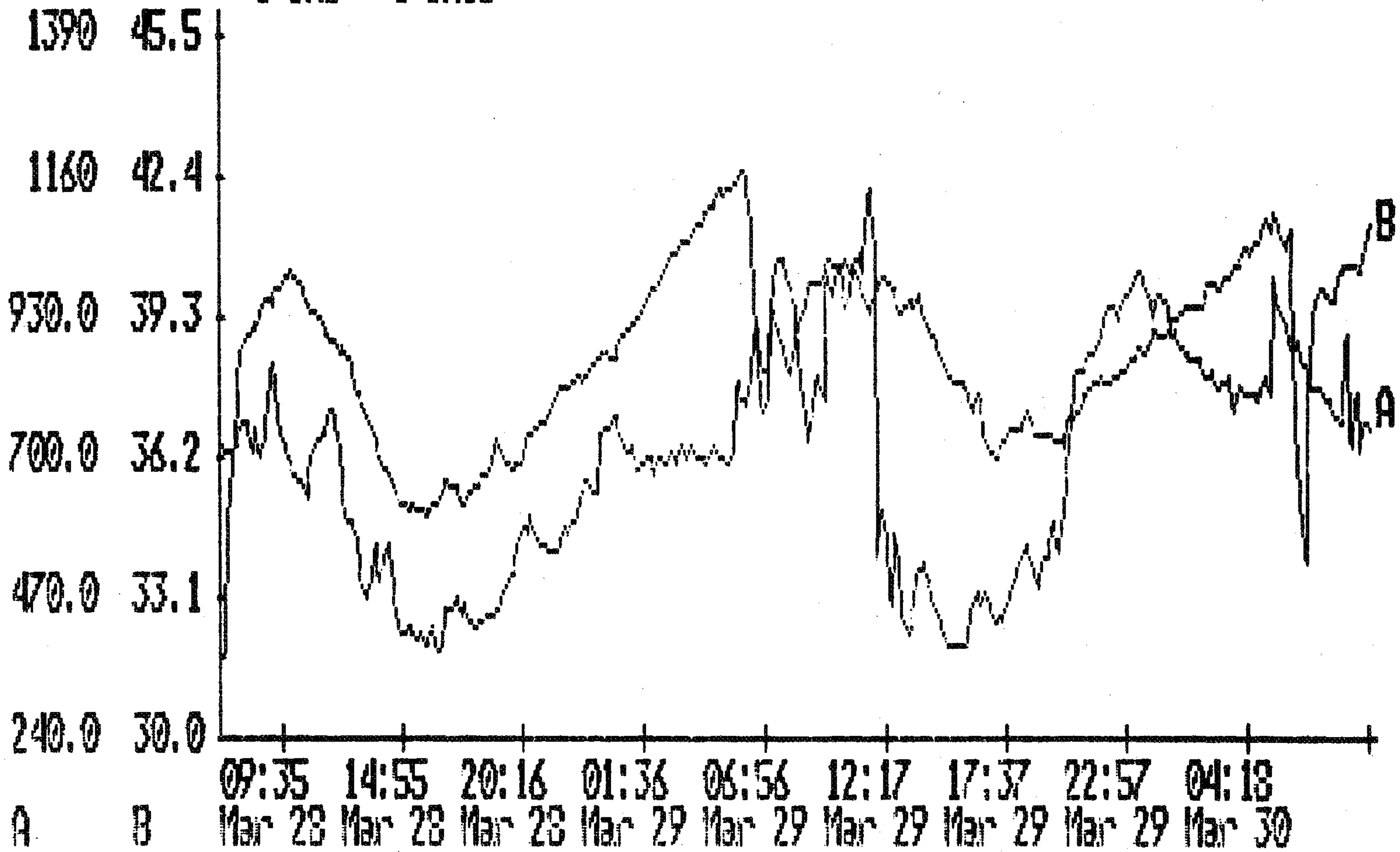
SECOND YEAR DATA

BURKE 1000

System: UNIT 6 - WALL INLET
0.15 ACH continuous
Panel : BEDROOM SAMPLE

Time: 0:46:20
Date: 1-01-80

ANALOG MONITOR 11 -- U6CO2/RH
1-IN2 1-IN16



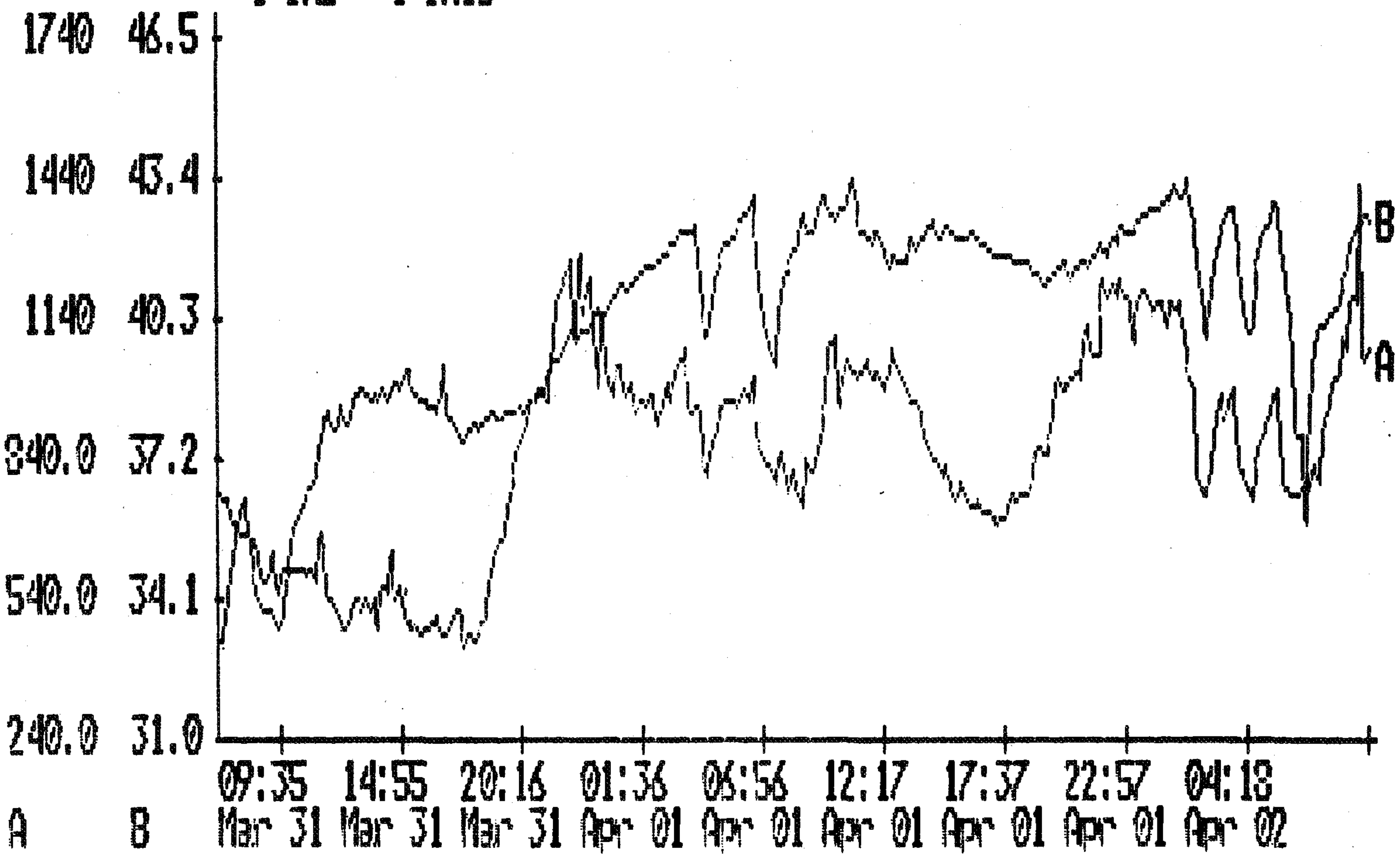
SECOND YEAR DATA

BURKE 1000

System: UNIT 6 - WALL INLET
0.3 ACH dehumidistat
Panel : BEDROOM SAMPLE

Time: 0:26:30
Date: 1-01-80

ANALOG MONITOR 11 -- U6CO2/RH
1-IN2 1-IN16

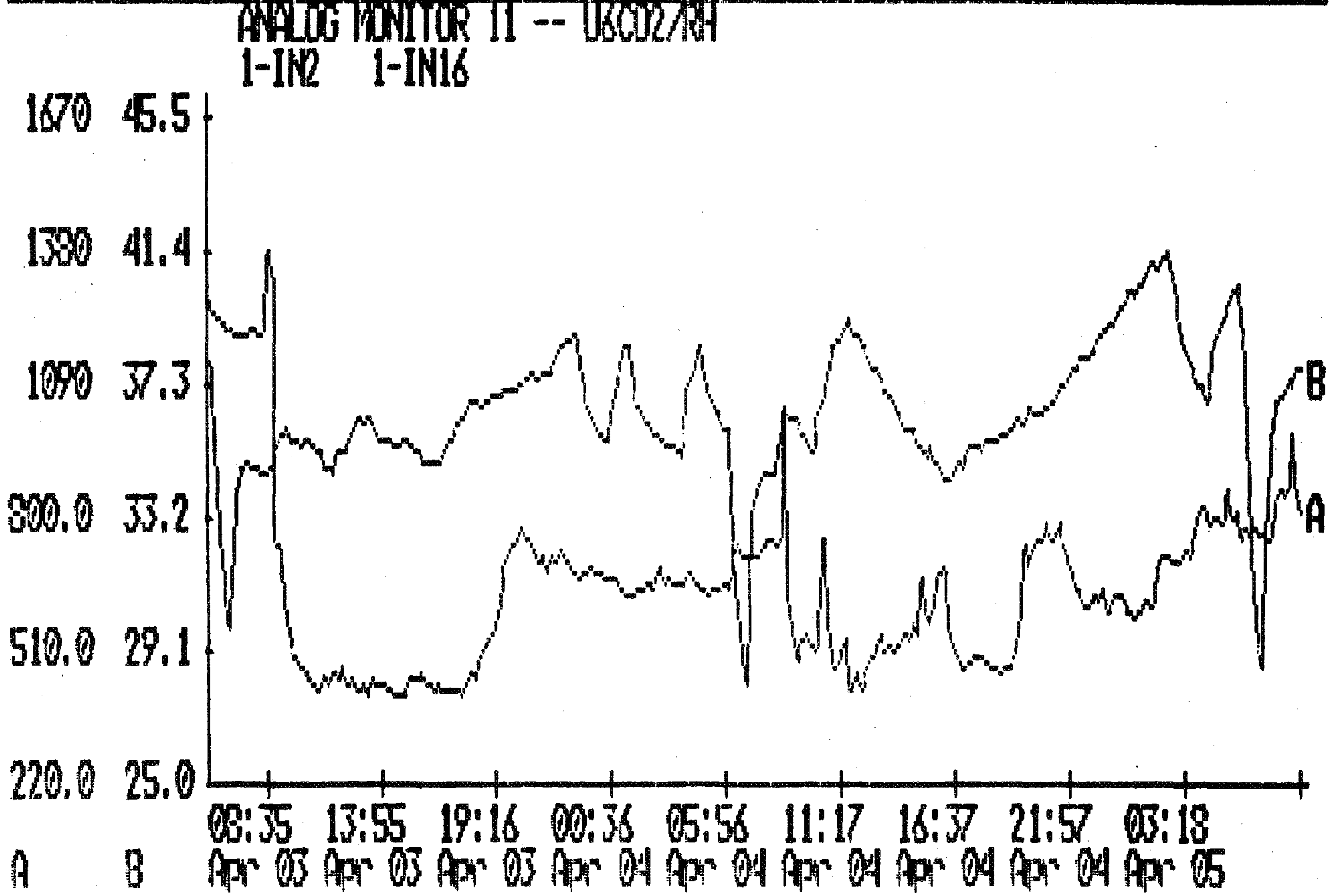


SECOND YEAR DATA

BURKE 1000

System: UNIT 6 - WALL INLET
0.3 ACH dehumidistat
Panel : MAIN LIVING AREA SAMPLE

Time: 4:21:34
Date: 6-13-90



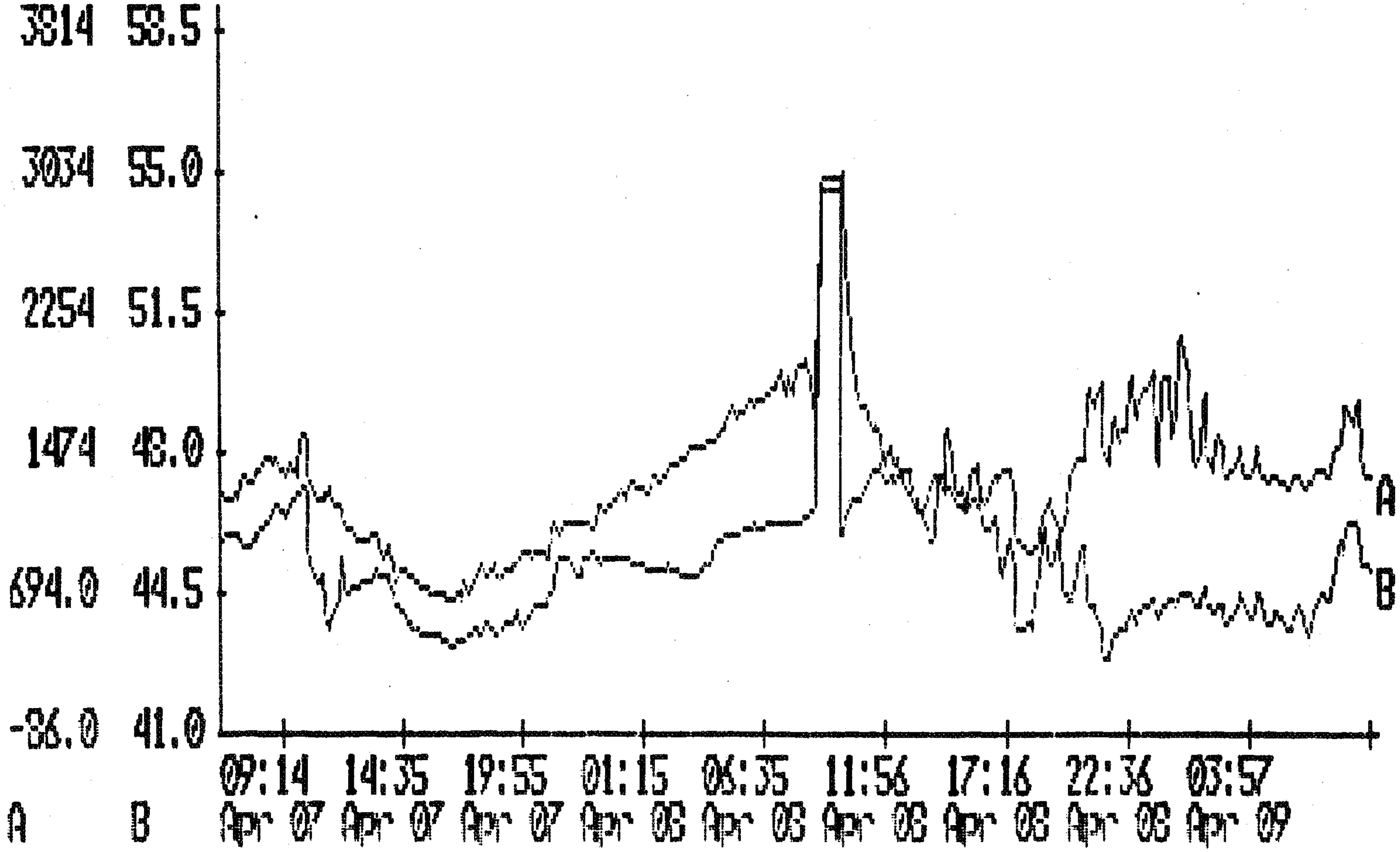
SECOND YEAR DATA

BURKE 1000

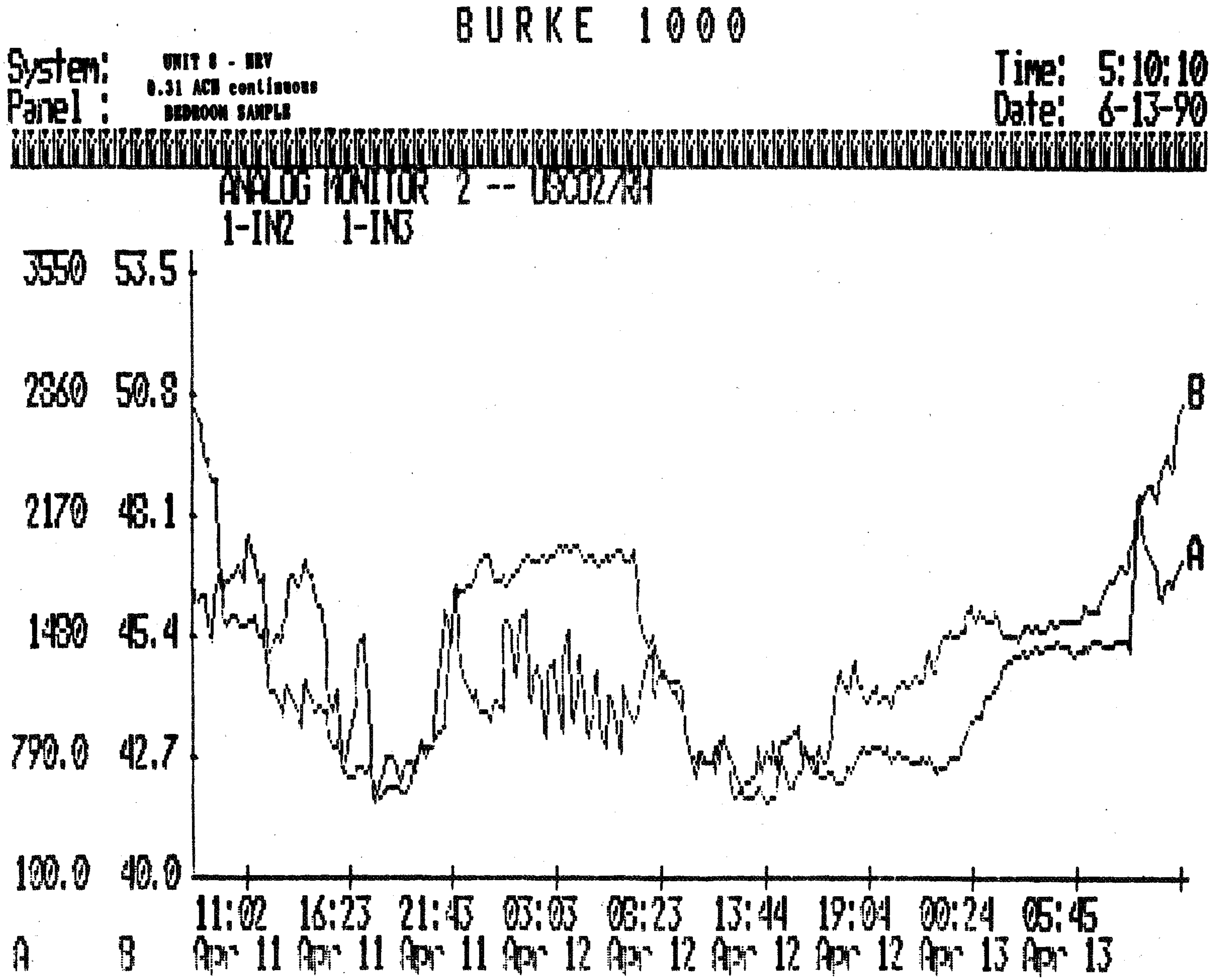
System: UNIT 8 - HRV
0.31 ACH continuous
Panel : MAIN LIVING AREA SAMPLE

Time: 4:34:15
Date: 6-13-90

ANALOG MONITOR 2 -- USCO2/RH
1-IN2 1-IN3



SECOND YEAR DATA

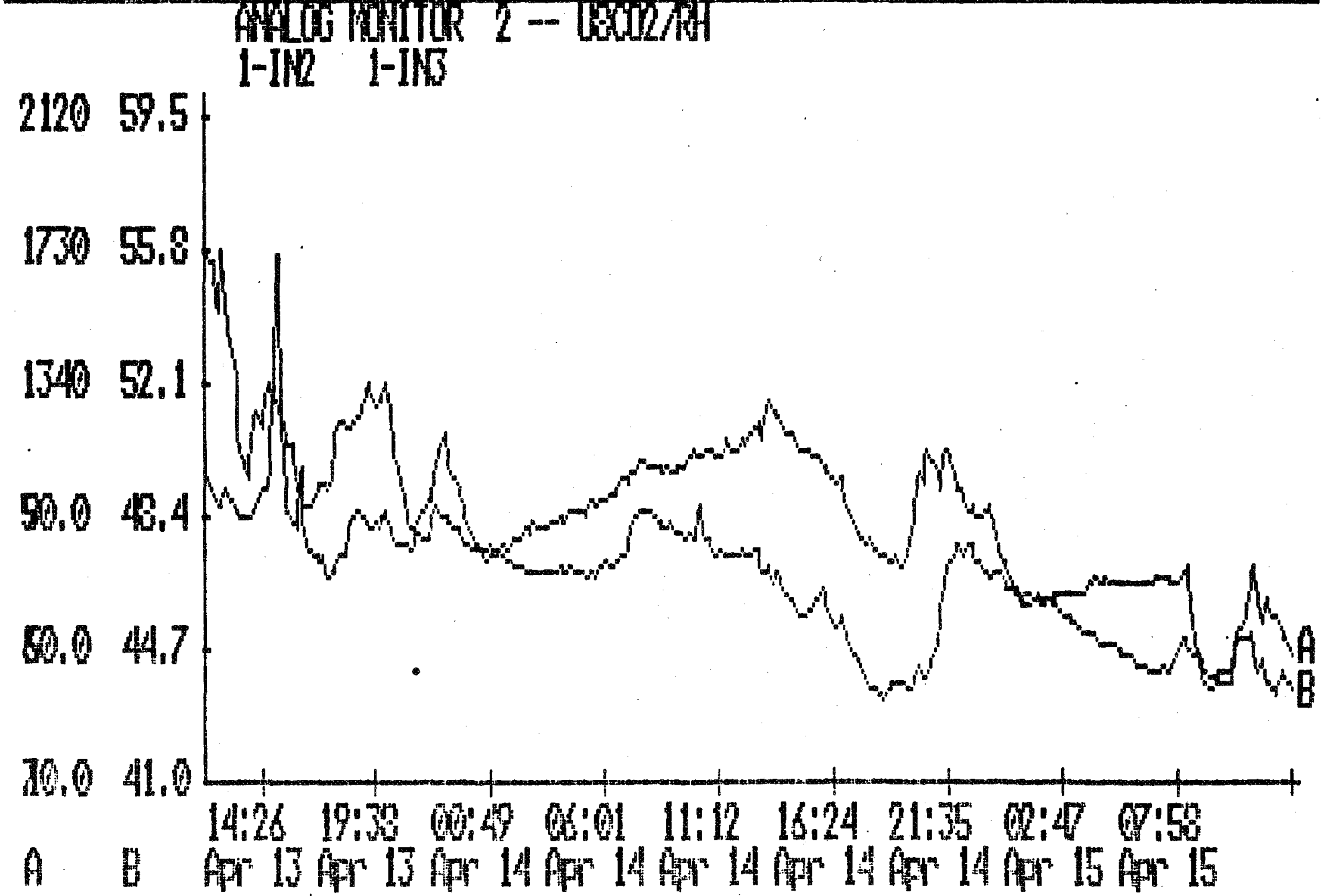


SECOND YEAR DATA

BURKE 1000

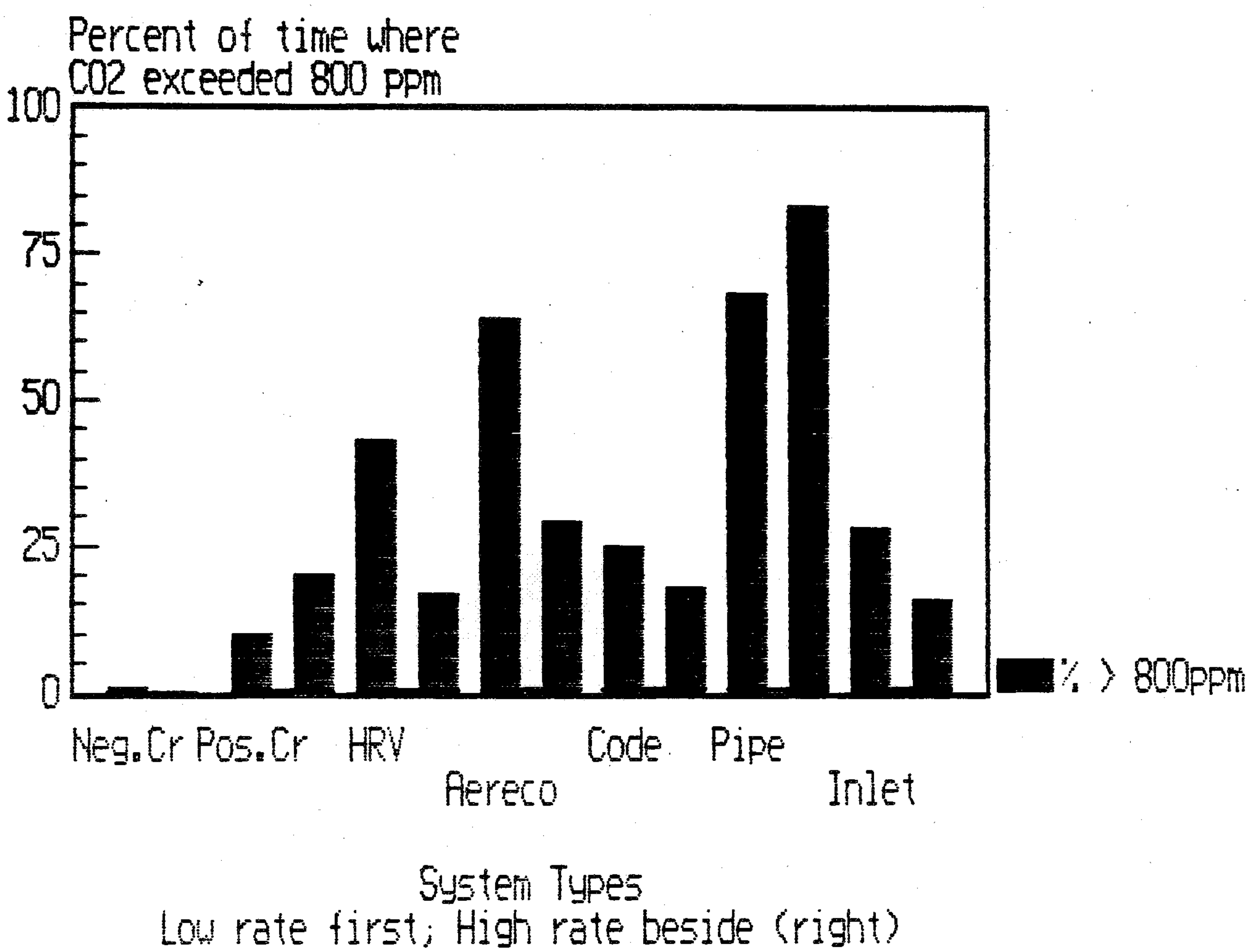
System: UNIT 6 - HRV
0.71 ACH continuous
Panel : BEDROOM SAMPLE

Time: 1:19:38
Date: 1-01-80

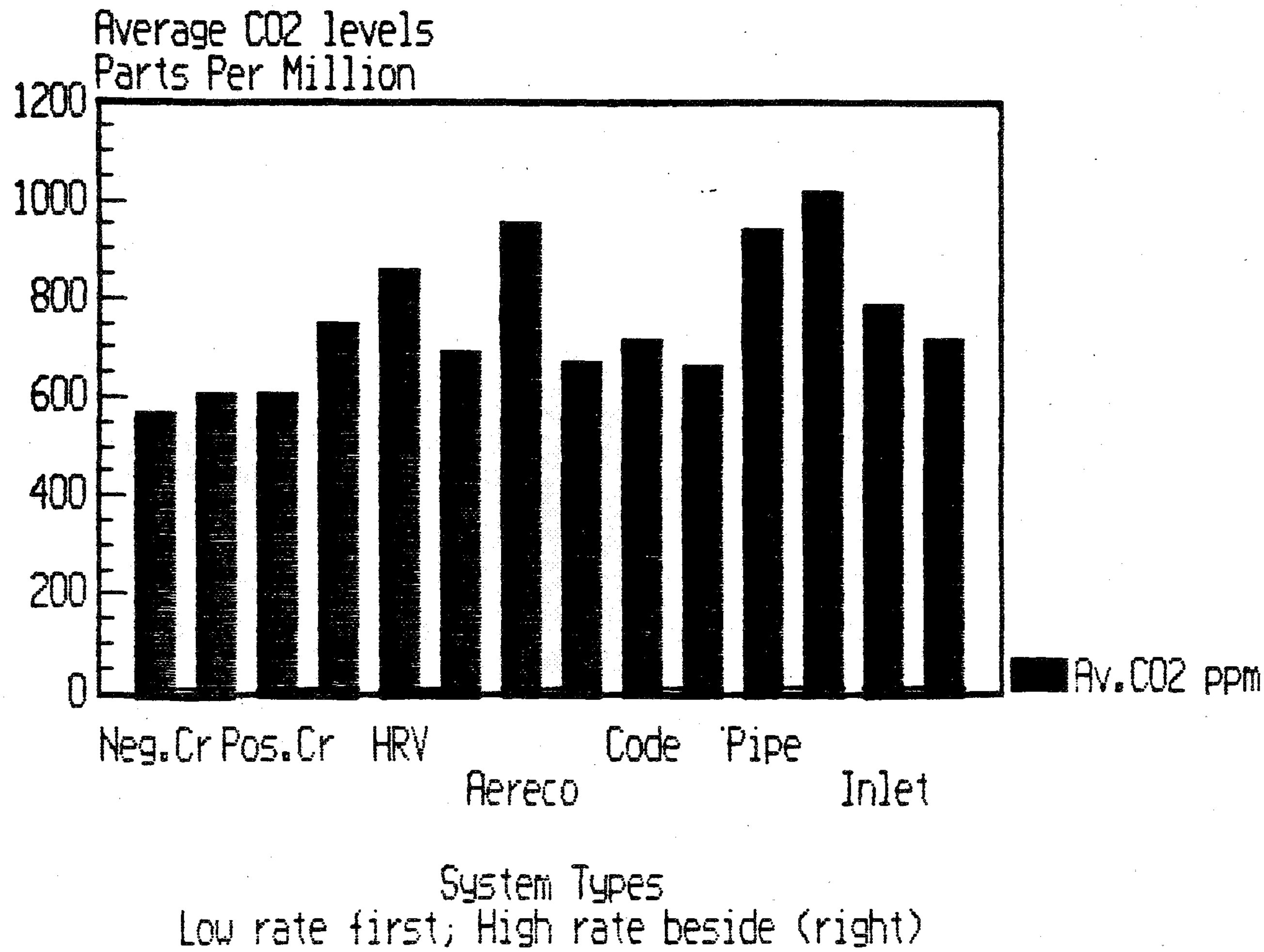


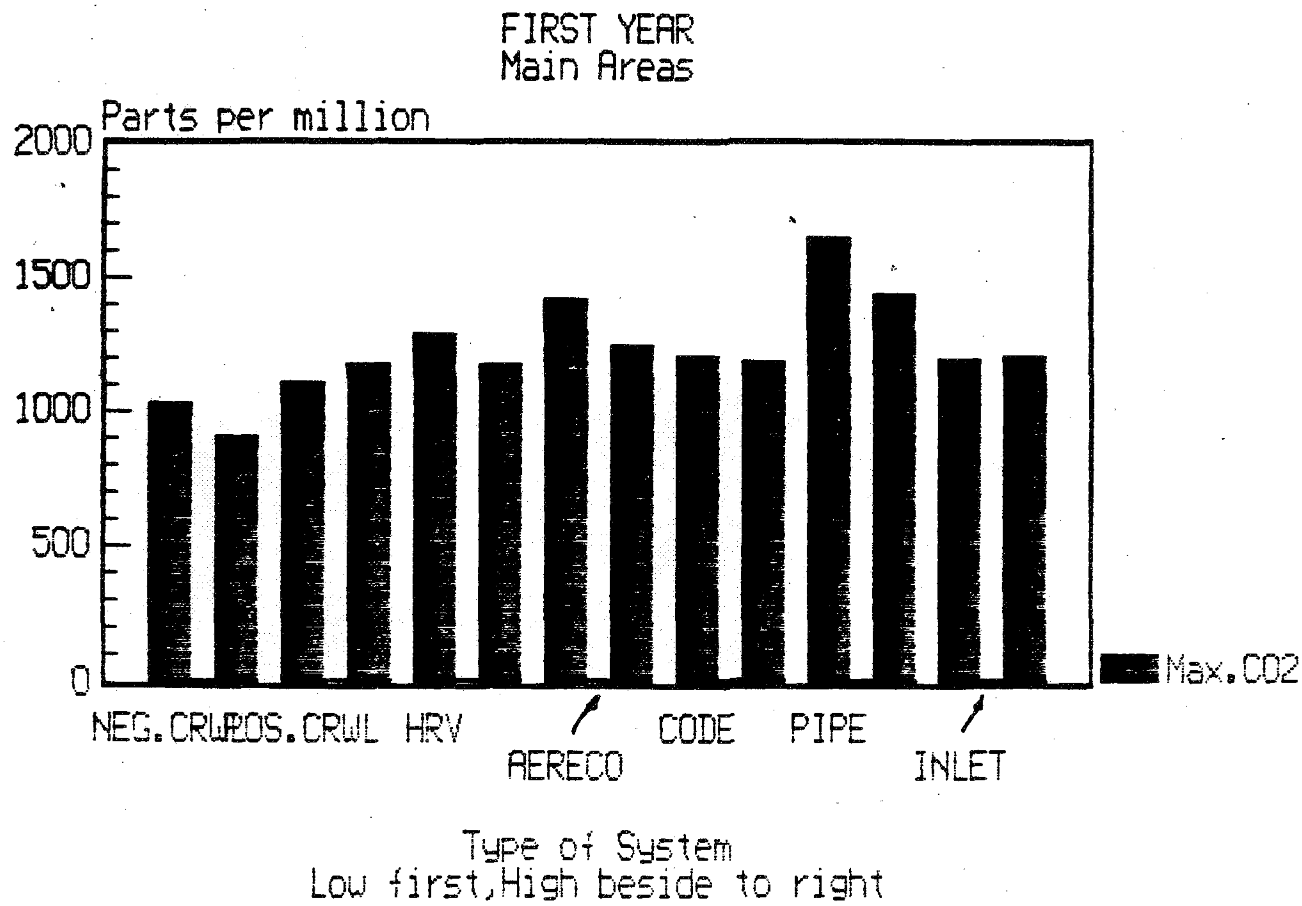
SECOND YEAR DATA

FIRST YEAR
Main Areas

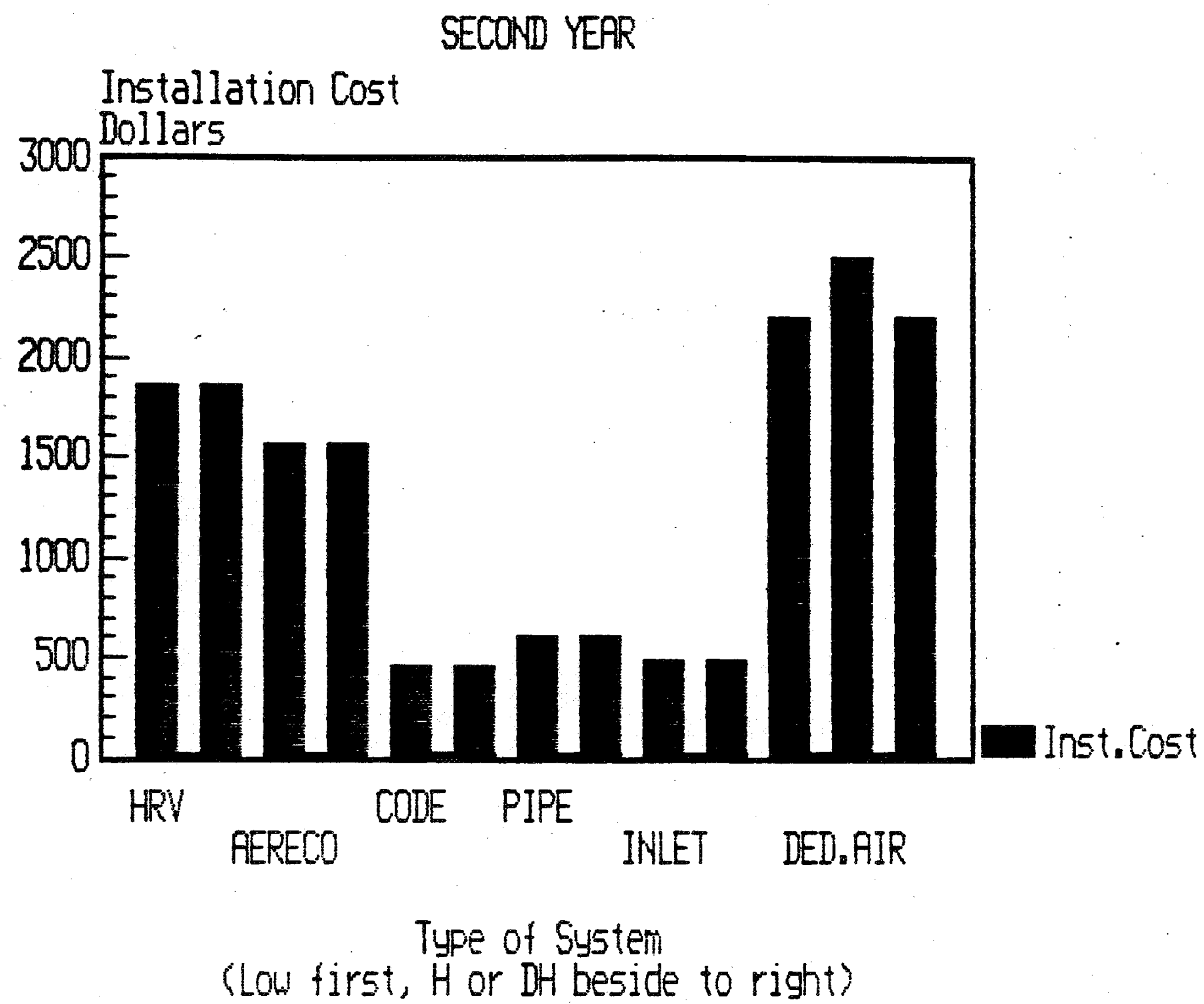


FIRST YEAR
Main Areas

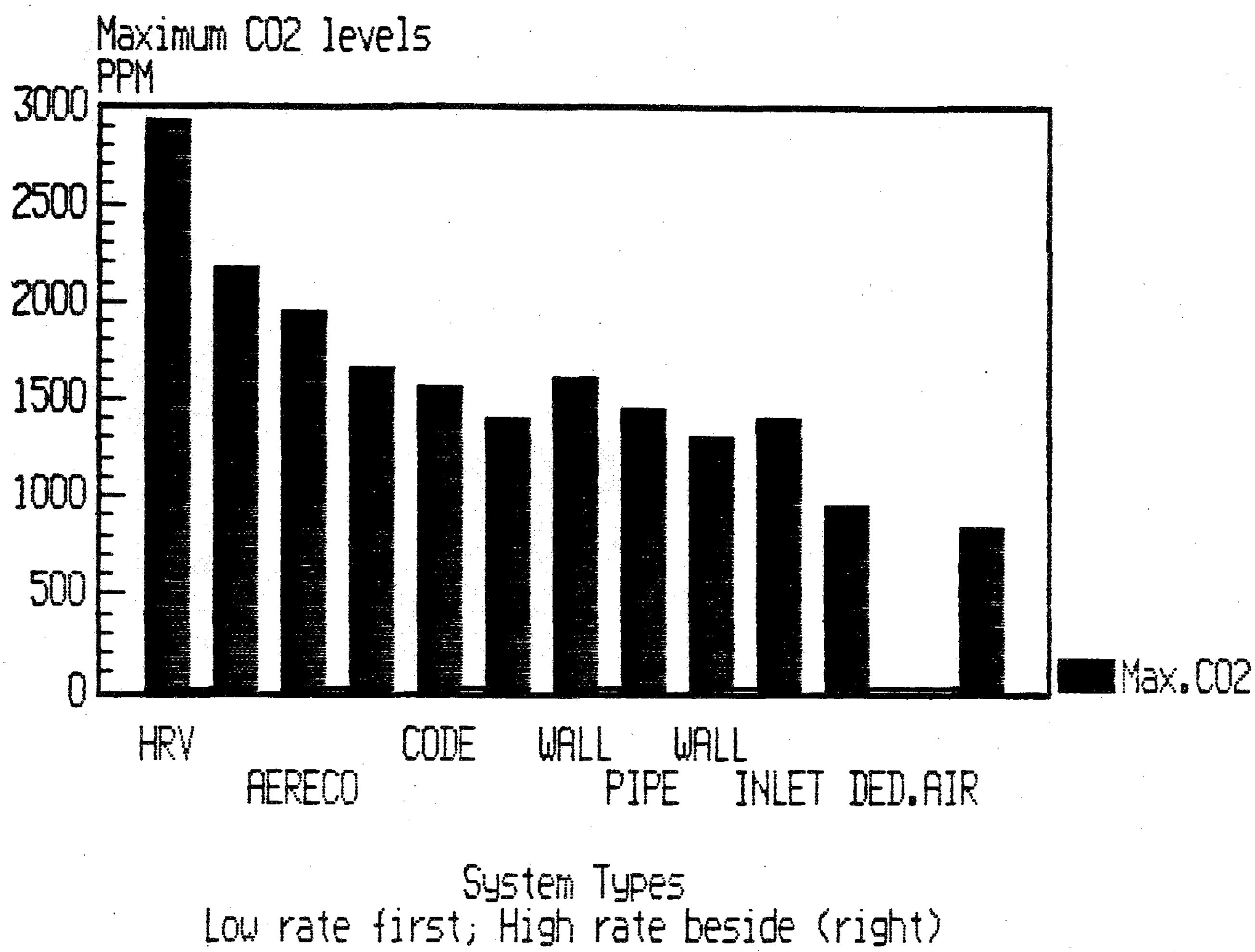


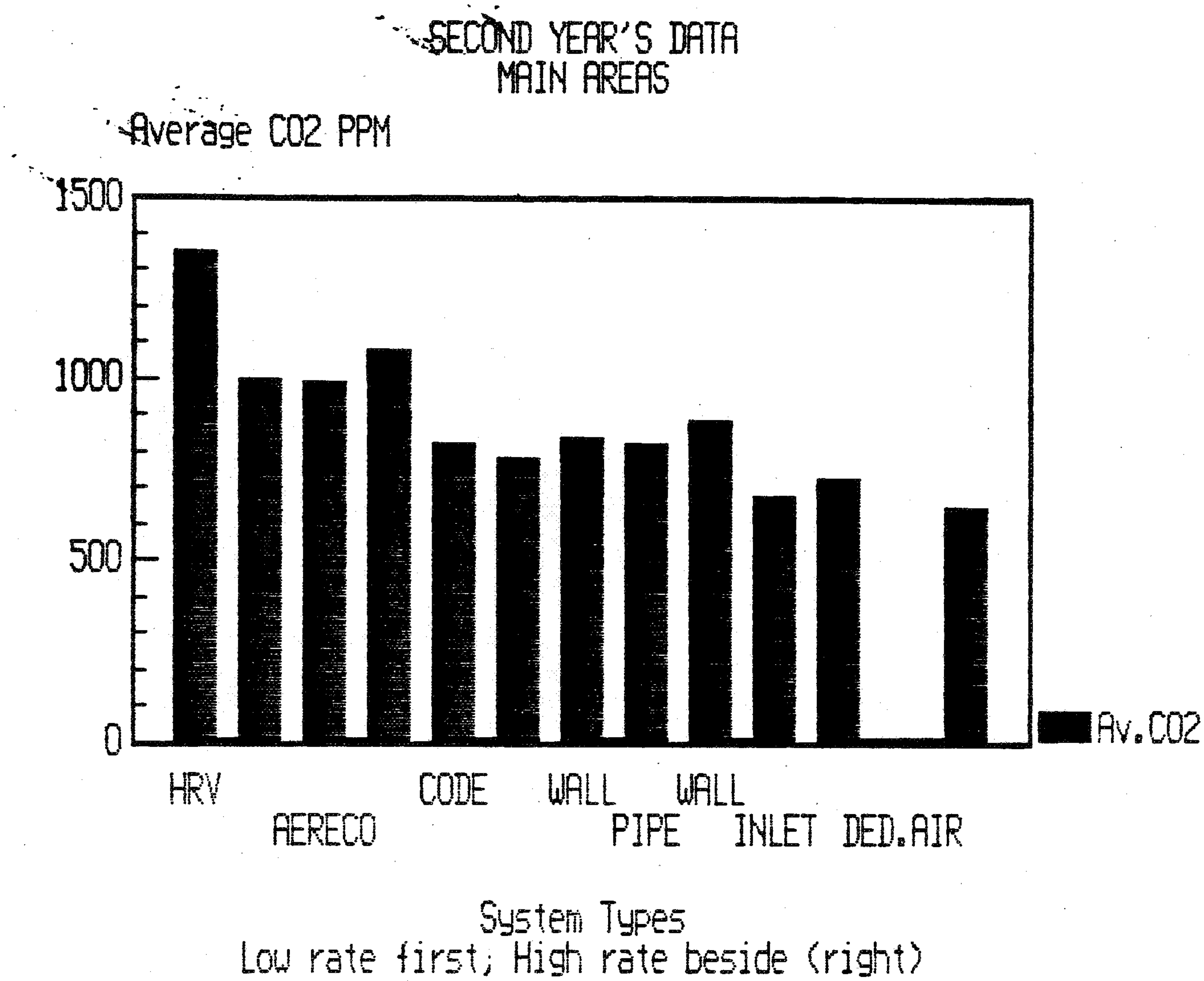


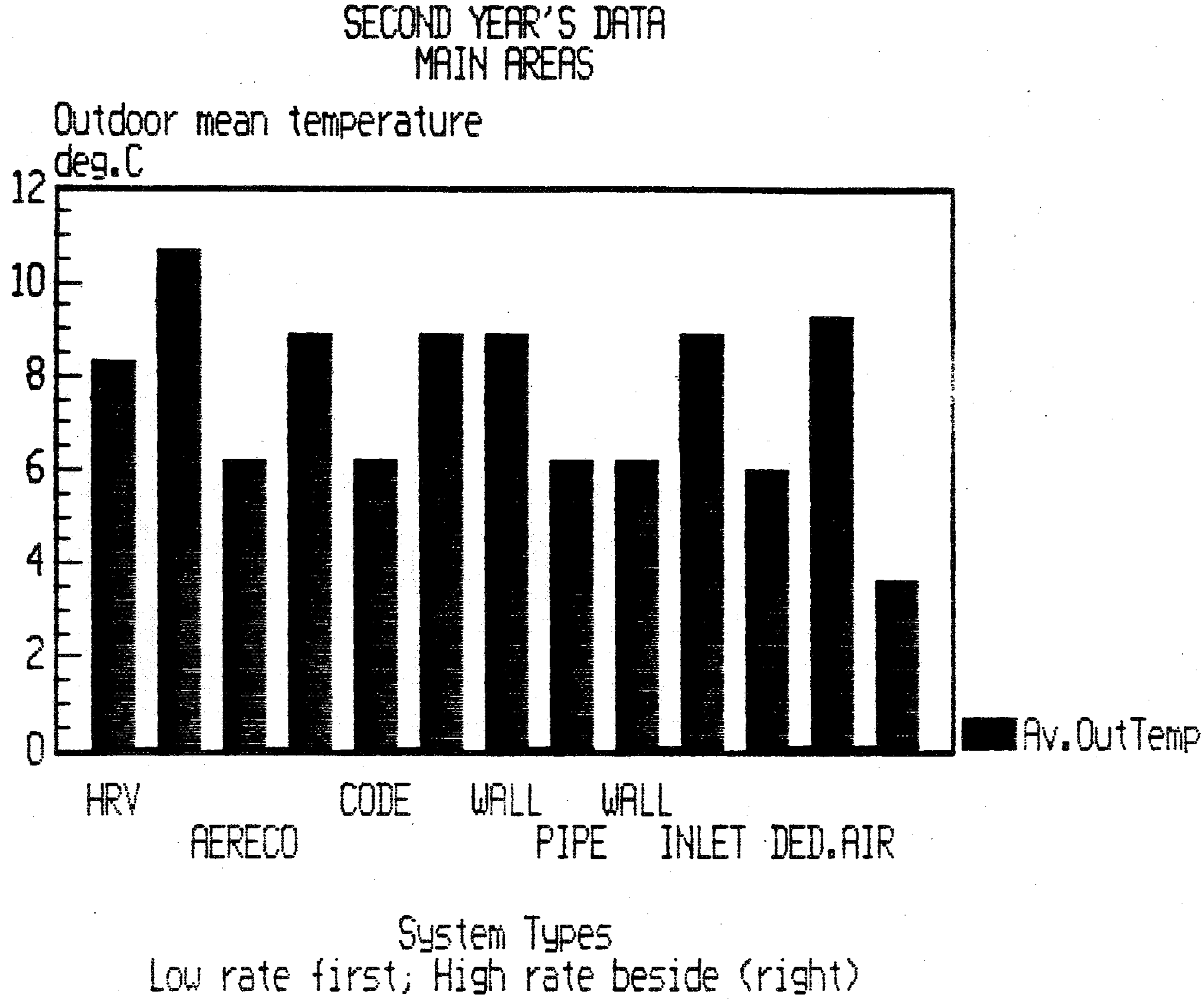
FIRST YEAR
Main Areas
Parts per million
2000
1500
1000
500
0
Max.CO2
NEG.CRWL
POS.CRWL
HRV
AERECO
CODE
PIPE
INLET
Type of System
Low first,High beside to right

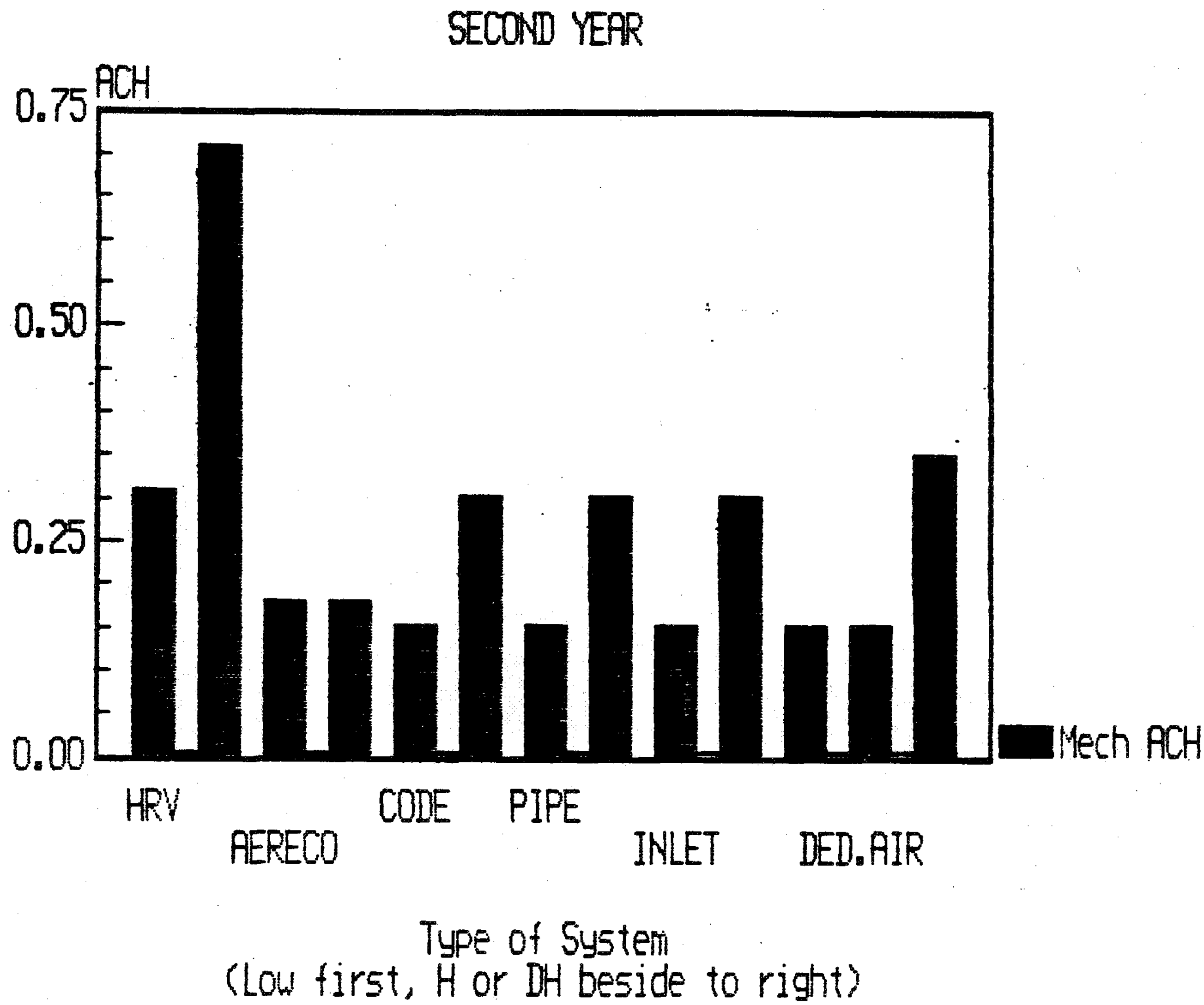

SECOND YEAR
Installation Cost
Dollars
3000
2500
2000
1500
1000
500
0
Inst.Cost
HRV
AERECO
CODE
PIPE
INLET
DED.AIR
Type of System
(Low first, H or DH beside to right)

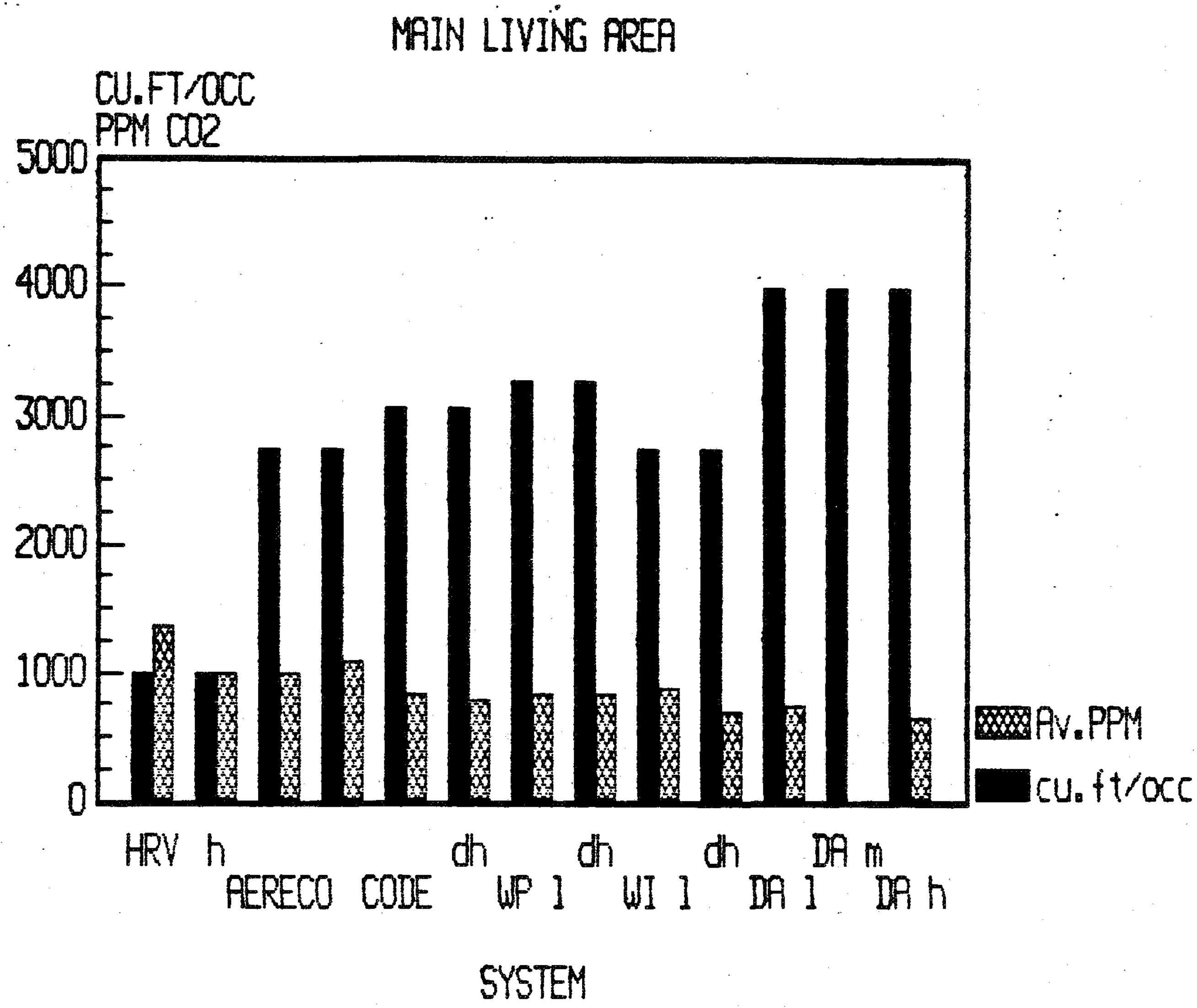
SECOND YEAR'S DATA
MAIN AREAS

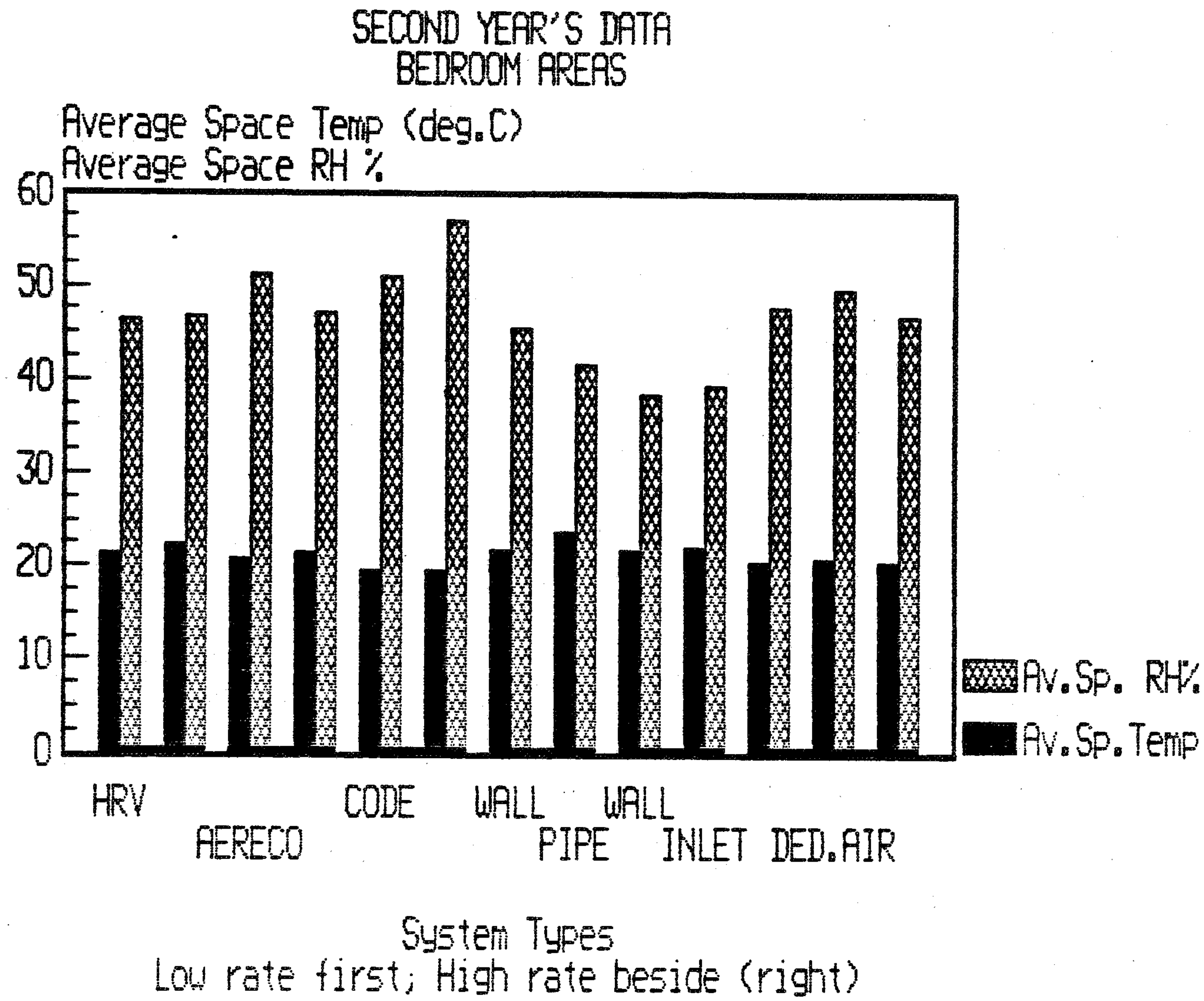


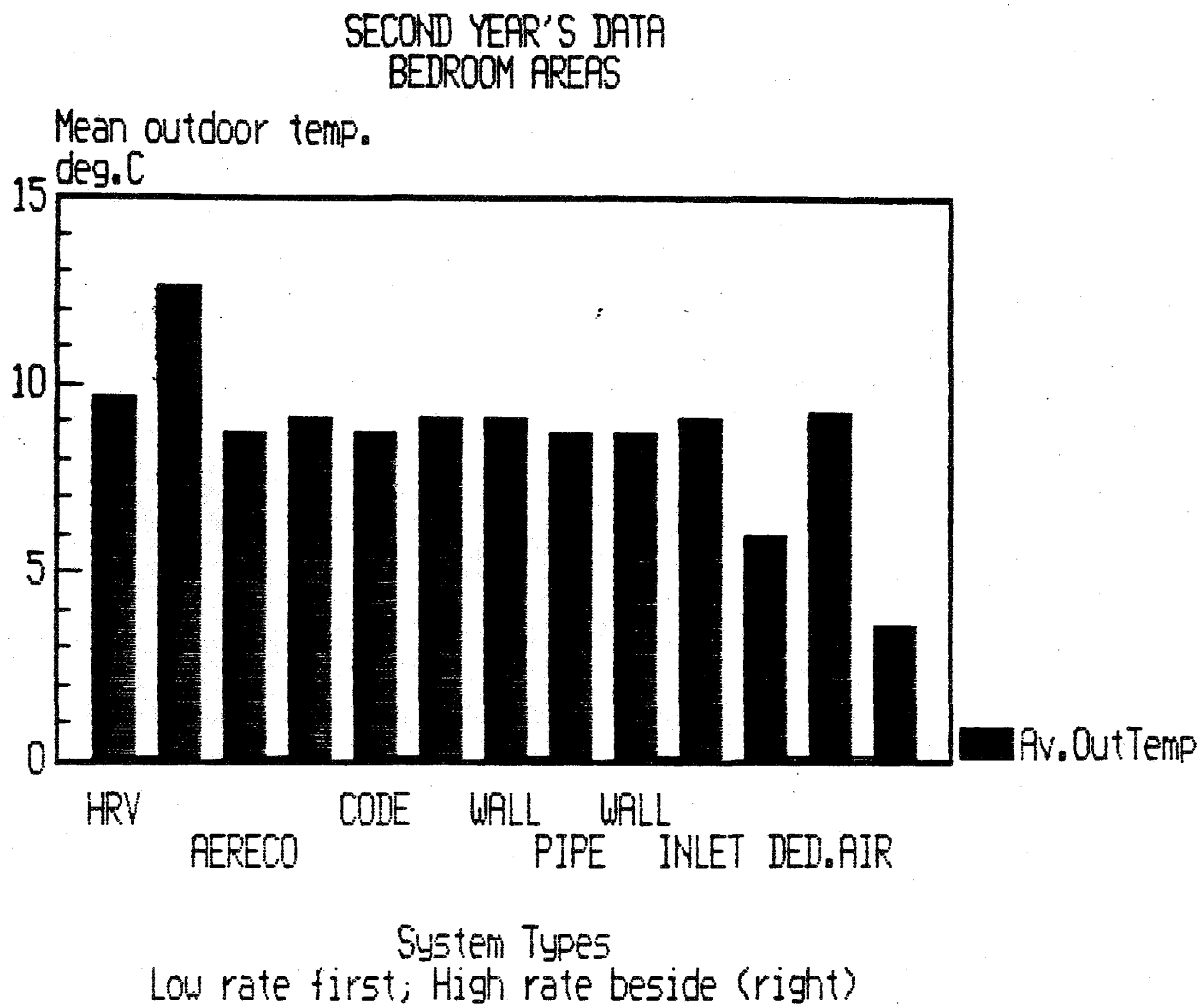

SECOND YEAR'S DATA
MAIN AREAS
Average CO2 PPM
1500
1000
500
0
Av.CO2
HRV
AERECO
CODE
WALL
PIPE
WALL
INLET
DED.AIR
System Types
Low rate first; High rate beside (right)


SECOND YEAR'S DATA
MAIN AREAS
Outdoor mean temperature
deg.C
12
10
8
6
4
2
0
Av.OutTemp
HRV
AERECO
CODE
WALL
PIPE
WALL
INLET
DED.AIR
System Types
Low rate first; High rate beside (right)


SECOND YEAR
ACH
0.75
0.50
0.25
0.00
Mech ACH
HRV
AERECO
CODE
PIPE
INLET
DED.AIR
Type of System
(Low first, H or DH beside to right)

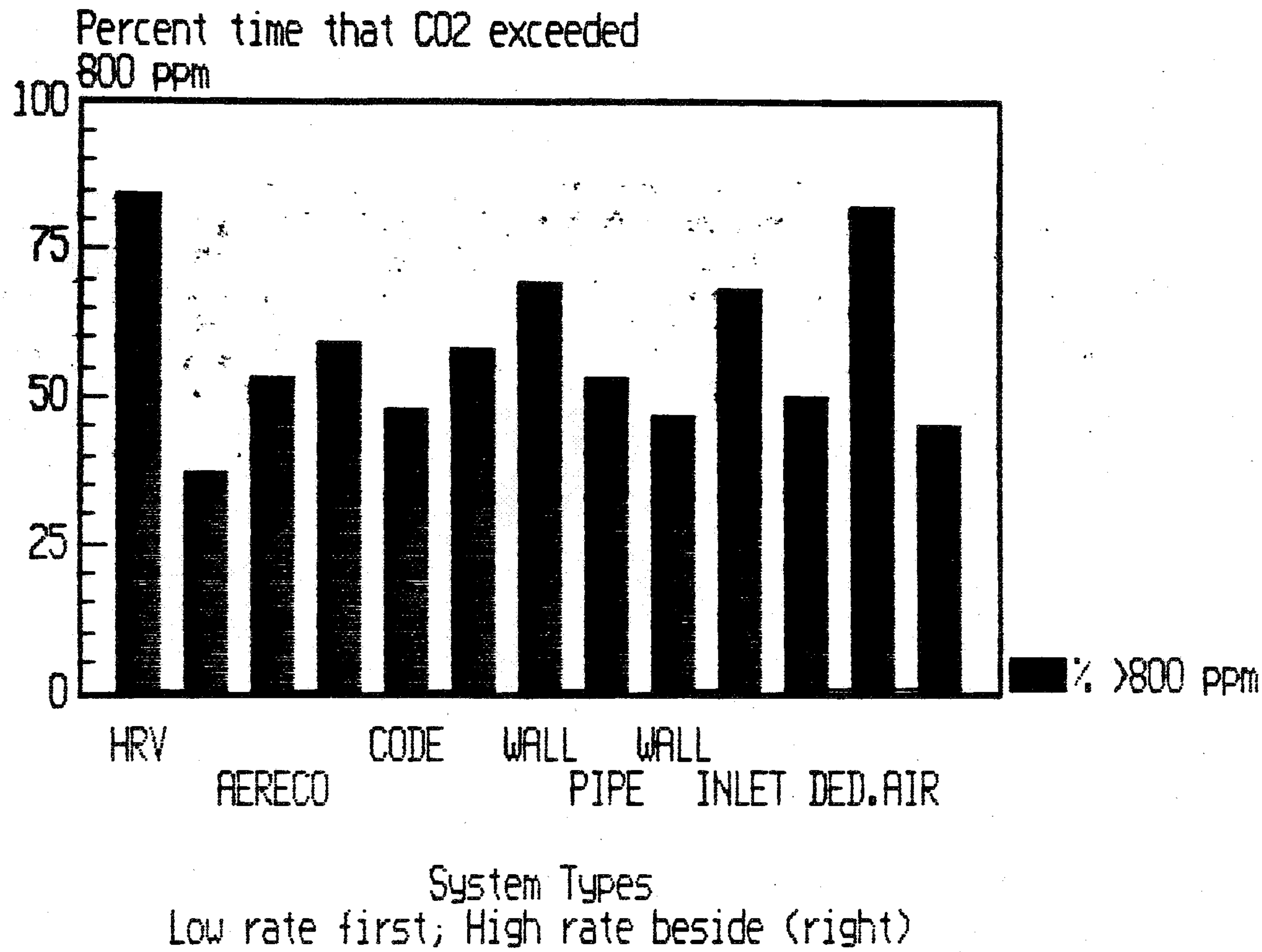

MAIN LIVING AREA
CU.FT/OCC
PPM CO2
5000
4000
3000
2000
1000
0
Av.PPM
cu.ft/occ
HRV
h
AERECO
CODE
dh
WP 1
dh
WI 1
dh
DA 1
DA m
DA h
SYSTEM

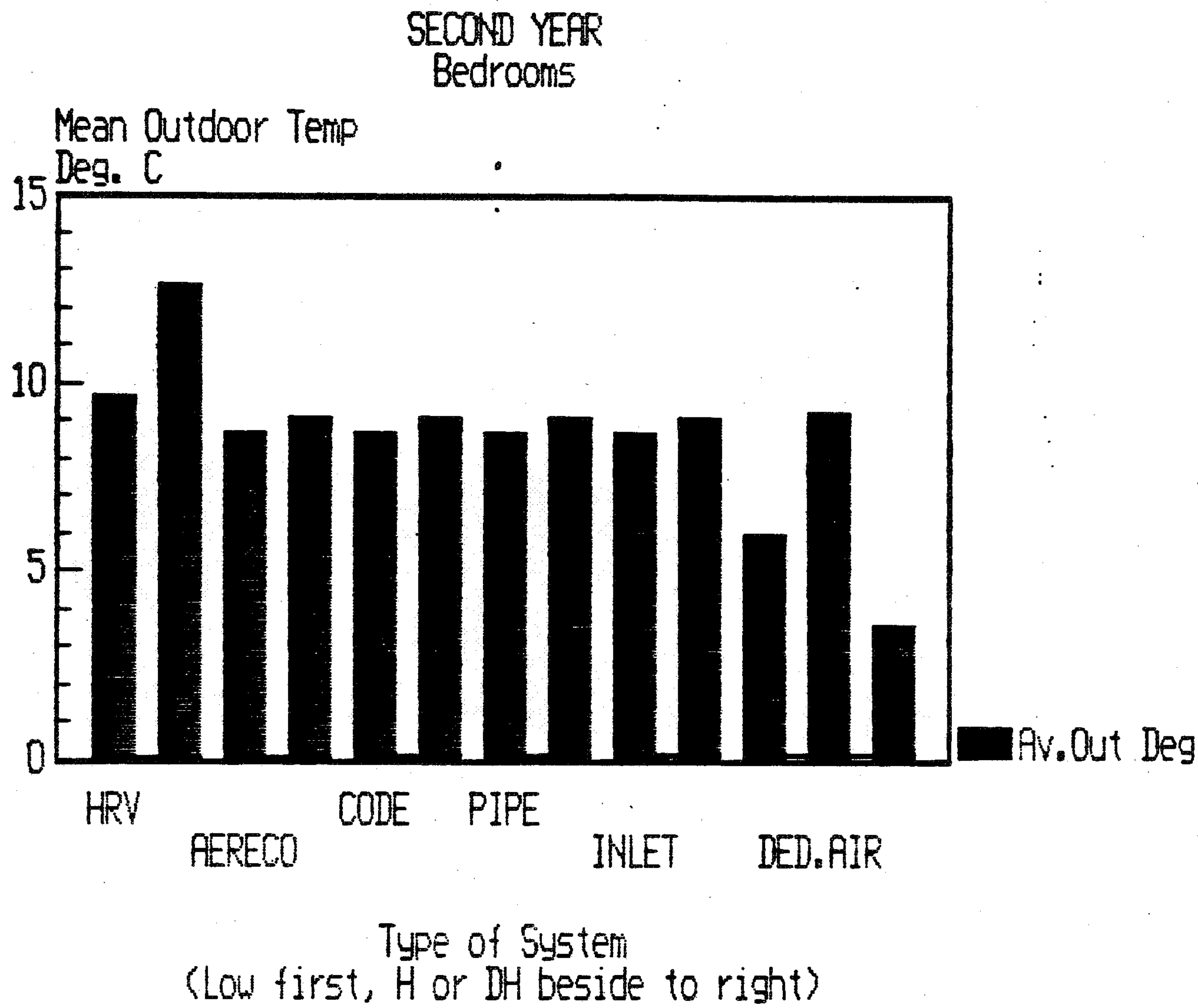

SECOND YEAR'S DATA
BEDROOM AREAS
Average Space Temp (deg.C)
Average Space RH %
60
50
40
30
20
10
0
Av.Sp. RH%
Av.Sp.Temp
HRV
AERECO
CODE
WALL
PIPE
WALL
INLET
DED.AIR
System Types
Low rate first; High rate beside (right)



SECOND YEAR'S DATA
BEDROOM AREAS
Mean outdoor temp.
deg.C
15
10
5
0
Av.OutTemp
HRV
AERECO
CODE
WALL
PIPE
WALL
INLET
DED.AIR
System Types
Low rate first; High rate beside (right)

SECOND YEAR'S DATA
BEDROOM AREAS




SECOND YEAR
Bedrooms
Mean Outdoor Temp
Deg. C
15
10
5
0
Av.Out Deg
HRV
AERECO
CODE
PIPE
INLET
DED.AIR
Type of System
(Low first, H or DH beside to right)

APPENDIX 6.

ENERGY PERFORMANCE

VENTILATION RELATED ENERGY COSTS

The operating costs of the respective ventilation systems are calculated using the following formula:

(FAN kW * 8760 H/y * USAGE % * $0.0467/kWh) + ((CFM * 1.1 * (TiAV - 43)F)/3412 * 5400 H/y * USAGE * $0.0467/kWh)

WATTS, USAGE and CFM from actual studied houses.

An average indoor temperature (TiAV) of 20 C is presumed for the continuously operated fan calculations. The figure used for the dehumidistat control mode calculation is taken from recorded data. Continuous fan figures are likely to be of greater use in comparing the energy performance of the various systems.

The calculations do not account for other heating season lengths, natural infiltration or costs of fuels other than electricity.

SYSTEM	WATTS	USAGE	CFM	TiAV	$/yr	$/SqFt yr
NEG.CR.L	84	100%	74	20	$185	$0.079
NEG.CR.DH	115	3%	148	20	$10	$0.004
POS.CR.L	84	100%	74	20	$185	$0.079
POS.CR.DH	115	5%	148	19	$16	$0.007
HRV LOW	63	100%	50	20	$56	$0.046
HRV HI	97	100%	115	22	$120	$0.098
AERECO 1	35	100%	28	20	$71	$0.062
AERECO 2	35	100%	42	19	$94	$0.081
CODE L	144	100%	23	20	$106	$0.092
CODE DH	144	98%	46	18	$136	$0.118
WALL PIPE L	35	100%	23	20	$61	$0.053
WALL PIPE DH	35	12%	46	25	$17	$0.015
WALL INLET LOW	35	100%	21	20	$57	$0.047
WALL INLET DH	35	2%	41	23	$2	$0.002
DA HRV F326	114	100%	140	20	$130	$0.044
DA HRV .15ACH	69	100%	60	20	$82	$0.027

NOTES: HRV sensible recovery efficiency = 70% low speed; 56% high. AERECO cfm's calculated from manufacturer's literature. All fans but HRV, CODE & CRAWLSPACE are AERECO product.

VENTILATION SYSTEMS:

NEG.CR.L = NUTONE 672 C-B;
POS.CR. = DELHI 530
AERECO = FULL AERECO SYSTEM
WALL PIPE = AERECO FAN
DED.AIR HRV = LIFEBREATH 200
NEG.CR.DH = BROAN 362 V
HRV = VANEE 1000
CODE L = NUTONE 695-B
WALL INLET = AERECO FAN

APPENDIX 7.

EXAMPLES OF RECOMMENDED SYSTEMS

EXAMPLES OF RECOMMENDED SYSTEMS

The following systems shown here:

1. **Minimum BC Code.** (see section 5.5 of report)

2. **Heat Recovery Ventilator.** (see section 5.3 of report)

3. **Central Exhaust with Fully Distributed Make-up Air.**

   This is essentially the same as the HRV system except that it has no heat recovery. The cost is marginally less than the HRV, but care must be taken to locate the make-up air discharges so as to minimize "dumping" of cold air on occupants.

4. **Forced Warm Air Furnace.**

   The arrival of natural gas to Vancouver Island is expected to result in more installations of this kind. The installed cost of this system may be similar to the cost of electric baseboards plus an HRV. If an HRV is used in conjunction with the furnace, costs will likely be higher than the baseboard example.

   Outdoor air is filtered and distributed to every room served by the furnace, and combustion appliances are not likely to back-draft, but house can be at positive pressure which may increase moisture migration to walls.

   If long-term energy costs are of high concern the HRV addition should be considered.

   There is an energy penalty associated with the fan power required for the furnace. It is hoped that the heating industry will provide options such as high efficiency fan motors, integrated heat recovery, and programmable ventilation in the near future.

CONTROLS: Any combination of continuous, switched, dehumidistat, rheostat or programmable control may be effective in a given home. Occupancy, layout, combustion appliances etc. are contributing factors to the choice of system.

SYMBOLS & ABBREVIATIONS:

E/A	Exhaust Air
O/A	Outdoor Air
S/A	Supply Air (conditioned O/A)
W/R	Washroom
	Fan
F	Forced Warm Air Furnace w/ 2 speed fan
HRV	Heat Recovery Ventilator

GENERAL NOTES:

1. Entire installation to conform to National Building and Fire Codes of Canada, B.C. Electrical Code, SMACNA Standards and manufacturer's specifications.

2. Provide all materials, equipment and labour required to make complete and functional ventilation systems as per the drawings.

3. The Mechanical Contractor shall arrange and pay for all permits and inspections necessary to meet local requirements.

4. Any alternate equipment for layout changes must be approved by designer.

5. All installed equipment to CSA approved.

6. All rectangular duct elbows, not shown as radius, shall contain turning vanes (applies to tees as well). Radius elbows to have R/D = 1.5.

7. Maximum slope of rect. duct transitions not to exceed 1" in 4".

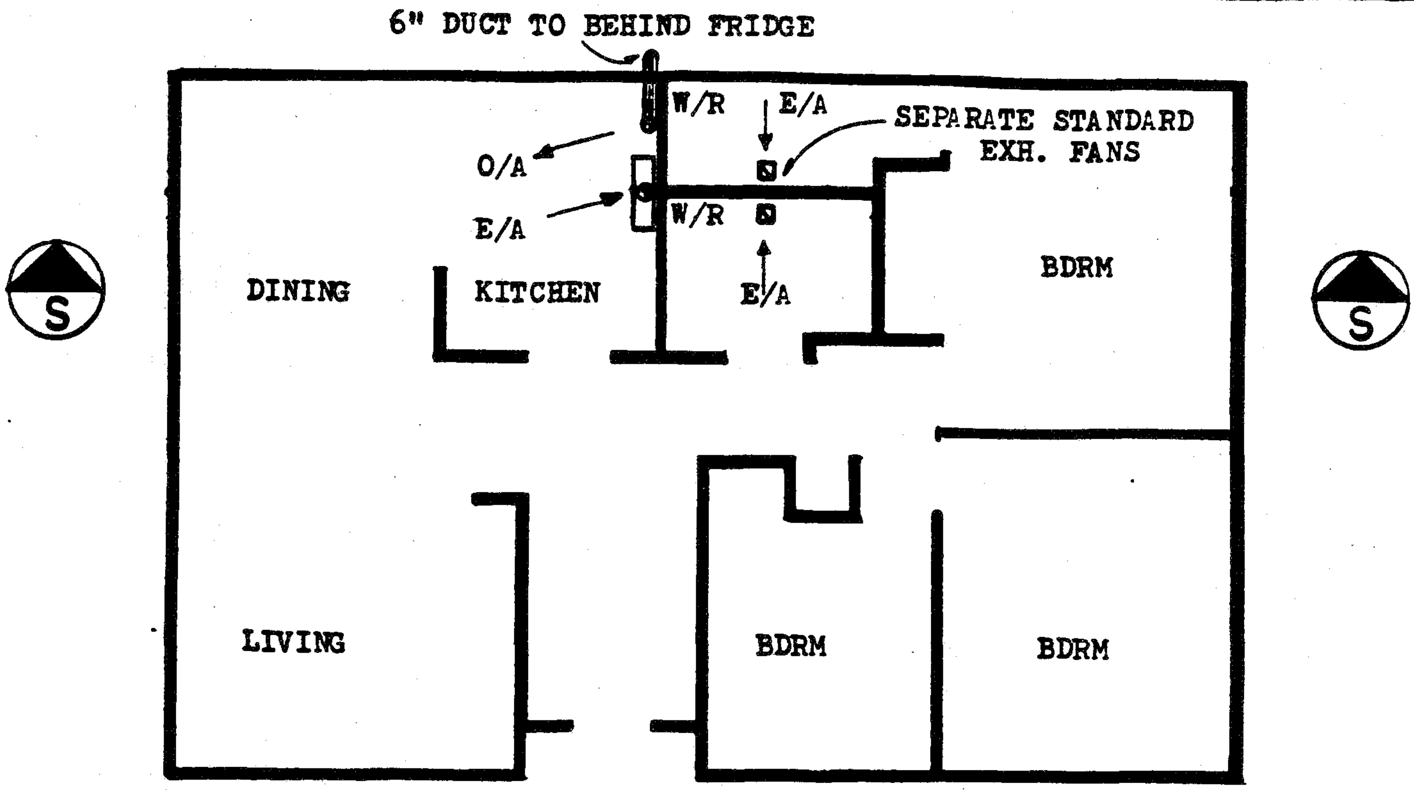
8. Maximum allowable continuous length of flex duct is 5 feet.

9. All duct joints to be continuous and sealed using duct tape or gum sealant.

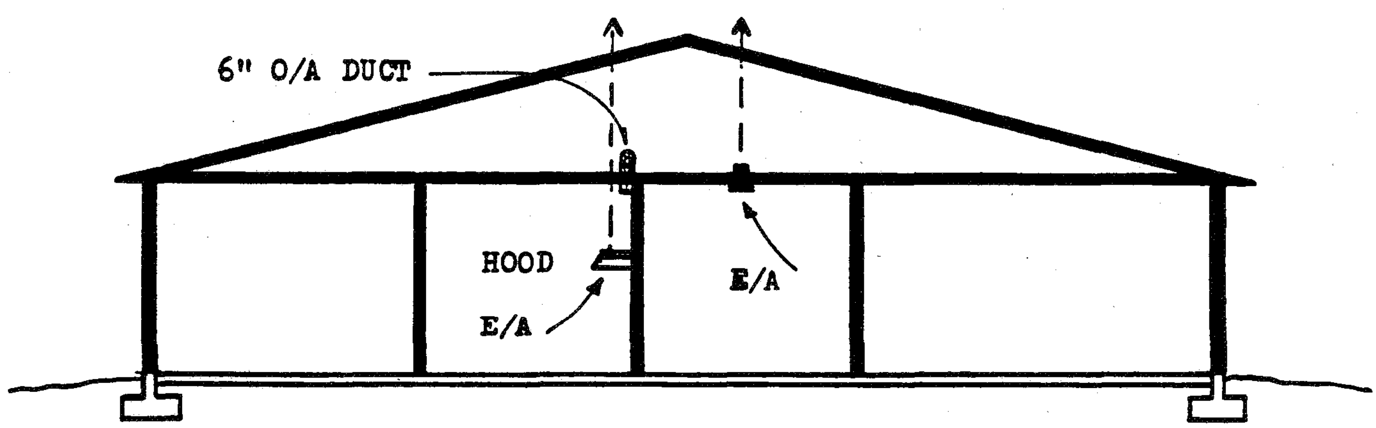
10. All ductwork shall be separated from the outdoors by minimum of R12.

11. Each S/A, O/A, and E/A branch duct shall contain a lockable quadrant volume damper.

12. All motorized air handling equipment, other than propeller W/R fans, shall be mounted with vibration isolation from structure.



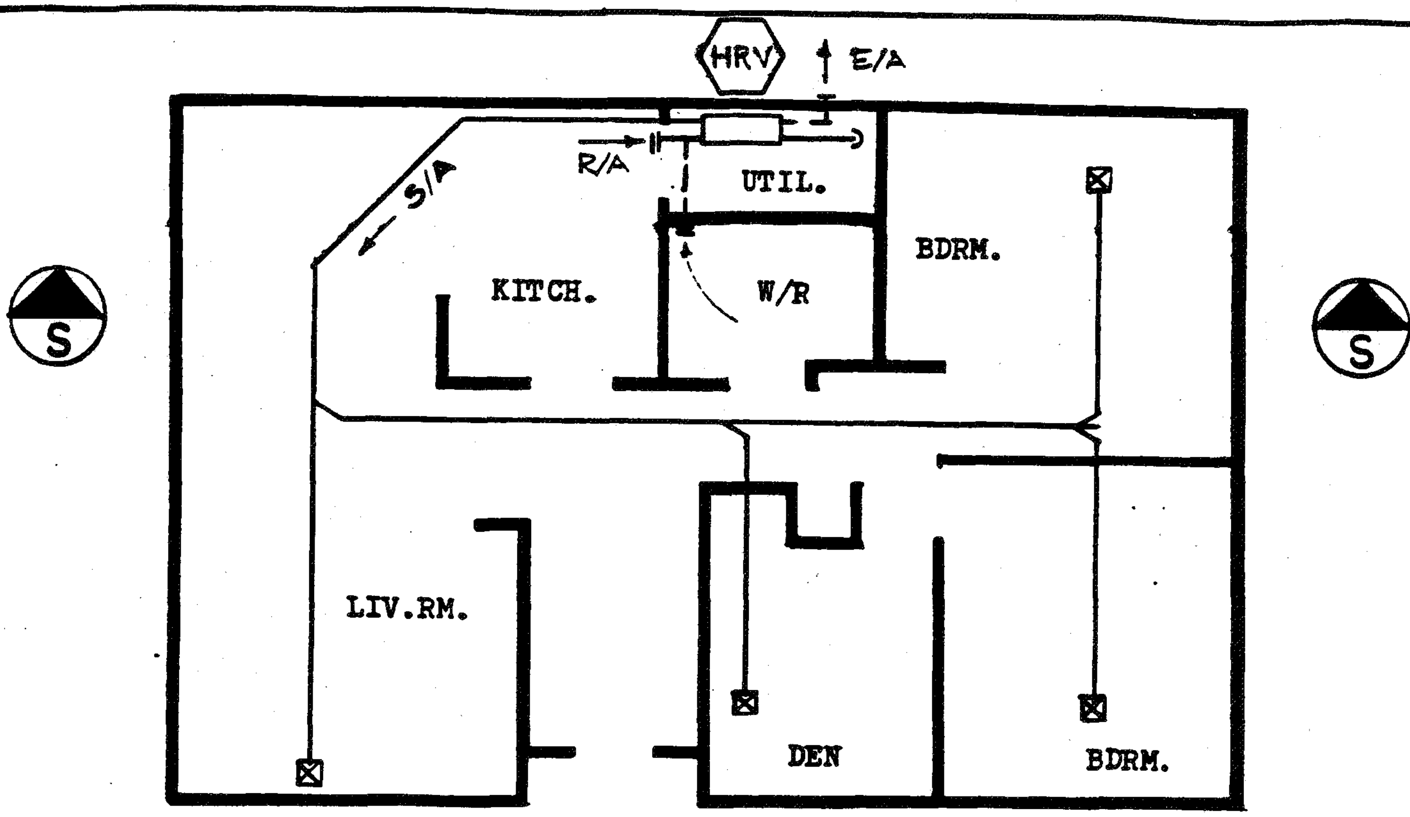
PLAN N.T.S.



SECTION

AVALON MECHANICAL CONSULTANTS

JOB TITLE	WEST COAST VENTILATION STRATEGIES	DRAWN BY	B.L.
		DATE	May 18,19[illegible]
SHEET TITLE	MINIMUM '85 N.B. CODE REQUIREMENT	CHECKED	
		DESIGN	



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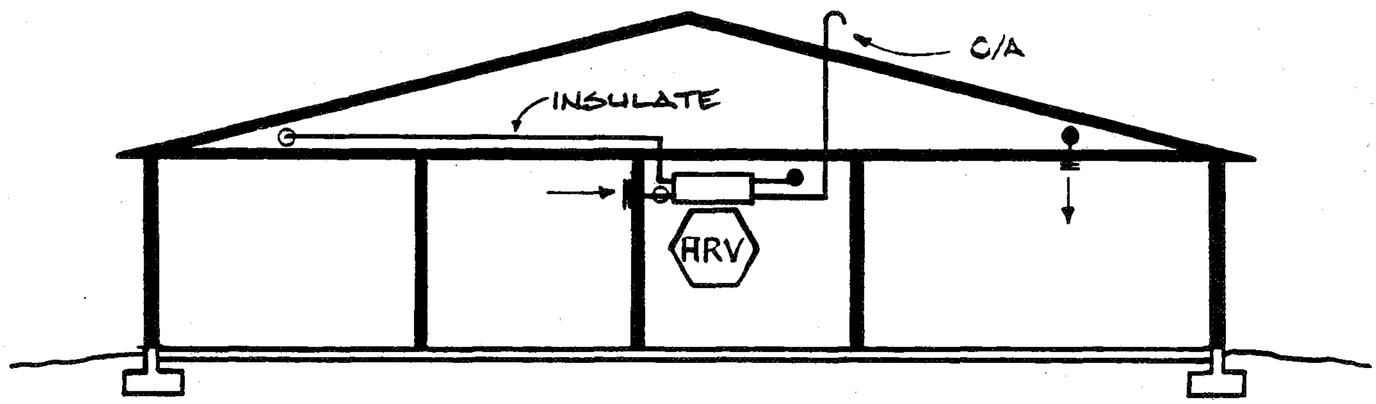
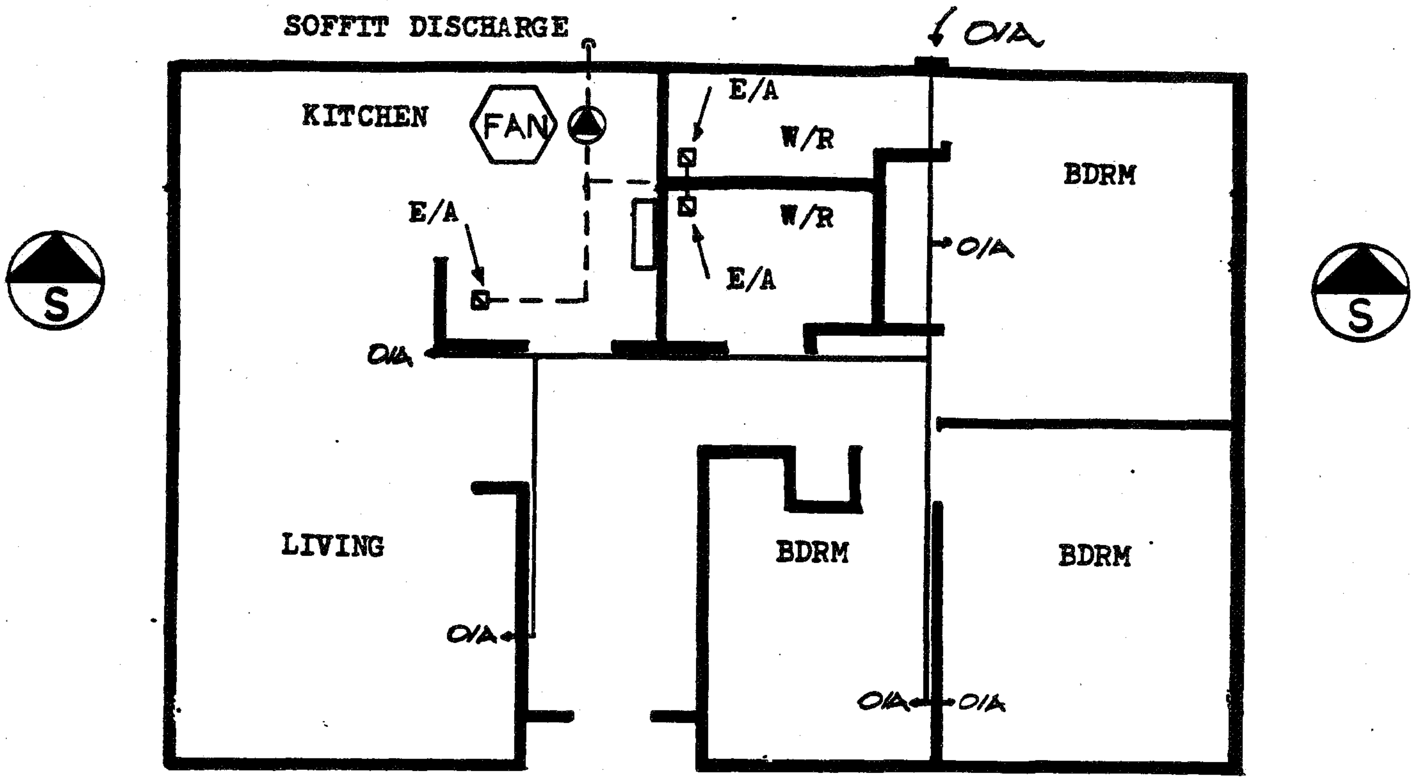


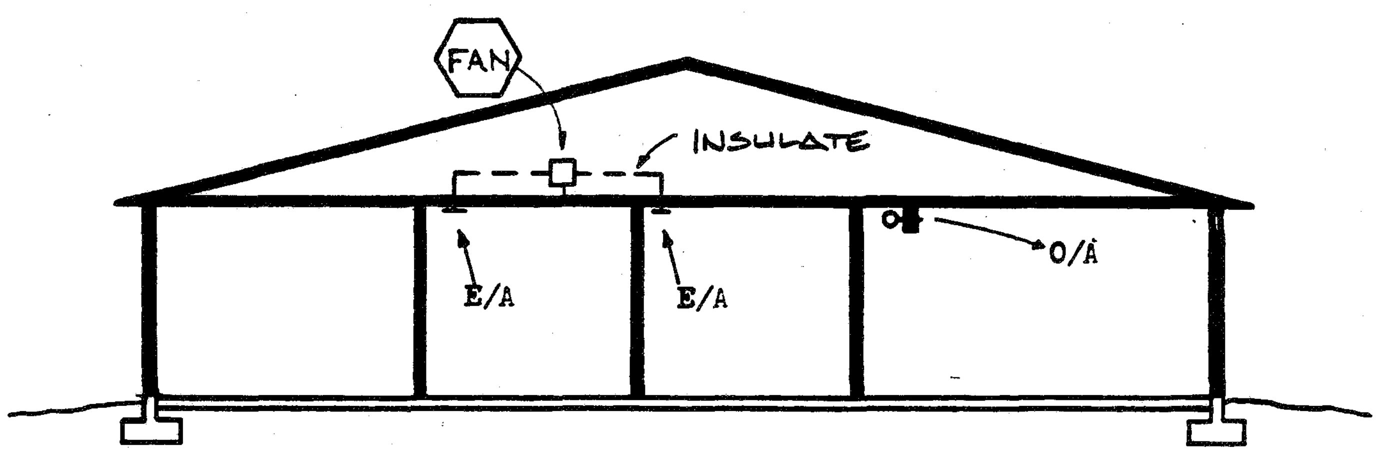
SECTION N.T.S.

AVALON MECHANICAL CONSULTANTS

JOB TITLE	WEST COAST VENTILATION	DRAWN BY	B.L.
		DATE	20/06/90
SHEET TITLE	HRV SCHEMATIC	CHECKED	
		DESIGN	



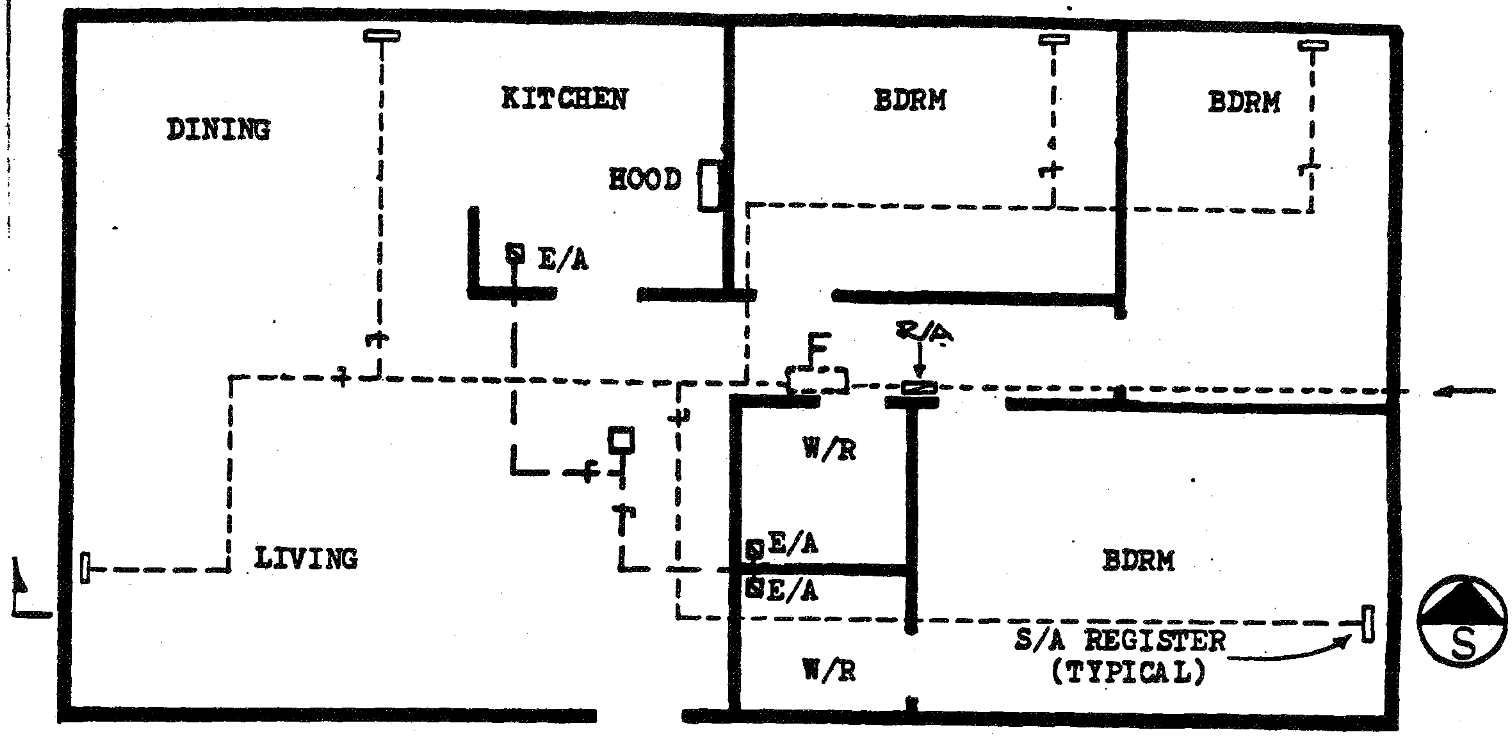
PLAN



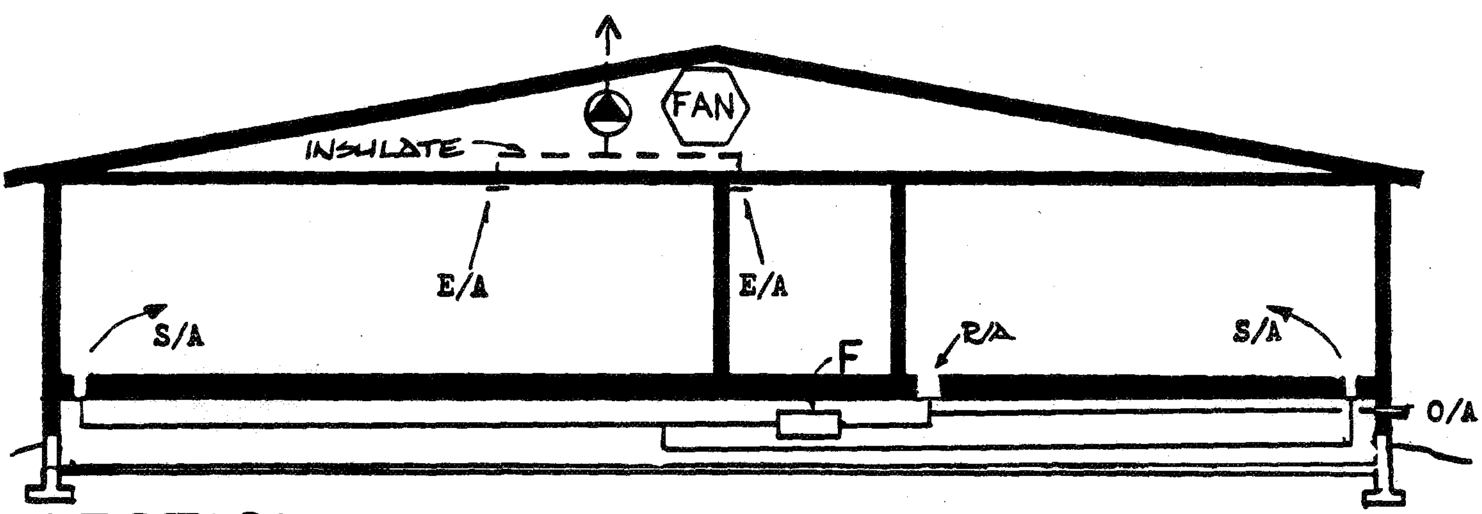
SECTION

AVALON MECHANICAL CONSULTANTS

JOB TITLE: WEST COAST VENTILATION STRATEGIES		DRAWN BY	B.L.
		DATE	May 18, 1990
SHEET TITLE: CENTRAL E/A; FULLY DISTRIBUTED O/A		CHECKED	
		DESIGN	



PLAN N.T.S.



SECTION

AVALON MECHANICAL CONSULTANTS

JOB TITLE	WEST COAST VENTILATION STRATEGIES	DRAWN BY	B.L.
		DATE	20/06/90
SHEET TITLE	FORCED WARM AIR FURNACE	CHECKED	
		DESIGN	

APPENDIX 8.

CHEMICAL TESTING RESULTS

CHEMICAL TESTING RESULTS

all results in parts per million (ppm)

FIRST YEAR		UNIT 3	UNIT 4	UNIT 5	UNIT 6	UNIT 8	HECTOR
formaldehyde		0.04	0.04	0.10	0.10	0.10	0.04
nitrogen dioxide	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	
toluene	< ppm range	< ppm range	< ppm range	<ppm range	< ppm range	< ppm range	
xylene	"	"	"	"	"	"	
limolene	"	"	"	"	"	"	
# of occupants		3	3	4	2	5	4

SECOND YEAR	UNIT 3	UNIT 4	UNIT 5	UNIT 6	UNIT 8	DEDICATED AIR
formaldehyde	not tested	not tested	< 0.01	not tested	< 0.01	not tested
# of occupants	3	3	3	3	9	6

JOHN M^ac^RAE & ASSOCIATES INC.

Environmental Health Services

90 06 19

Mr. Bob Landel
Avalon Mechanical Consultants Ltd.
4 - 1322A Government Street
Victoria, BC
V8W 1Y8

RE: Formaldehyde Sampling
2749 Jacklin Road

Dear Mr. Landel:

On 90 04 02 two (2) air samples (#1 and #2) were collected to determine airborne concentrations of formaldehyde. Sample #1 was collected in Suite #5 and sample #2 was collected in Suite #8. The samples were collected with battery operated pumps and midget impingers following the Workers' Compensation Board's Method No. 2250: Aldehydes, C_1 - C_4 In Air. The samples, including a "blank" (#3) were submitted to an independent laboratory for analysis.

The laboratory has reported results of <0.1 ug/mL for all samples resulting in a sample concentration of <0.01 ug/L and an airborne concentration of <0.1 ppm. All sample results were less than the quantitation limit.

Attached please find our Air Sample Log.

Yours truly,

JOHN MACRAE & ASSOCIATES INC.

John MacRae

JM/ab

100 -1144 FORT ST.
VICTORIA, B.C.
CANADA V8V 3K8
Telephone (604) 380-3911
Cellular (604) 727-1123
Fax (604) 380-1123

AIR SAMPLE LOG

John MacRae & Associates, Inc.

PROJECT: Housing Project, Jacklin Road

DATE	START TIME	READOUT TIME	TOTAL MINUTES	COUNT	FLOW RATE	VOL./AIR (LITRES)	LOCATION	TYPE	SAMPLE #	SAMPLE CONCENTRATION ug/L	AIRBORNE CONCENTRATION
90 04 02	12:16	12:38	22	N/ap	1.0	22	Suite #5	Area	1	<0.01	<0.1 ppm
90 04 02	12:21	12:41	20	N/ap	1.0	20	Suite #8	Area	2	<0.01	<0.1 ppm
90 04 02	Blank	-	-	-	-	-	-	Blank	3	<0.01	Blank

All samples less than quantitation limit.

Environmental Health Services

90 06 19

Mr. Bob Landel
Avalon Mechanical Consultants Ltd.
4 - 1322A Government Street
Victoria, BC
V8W 1Y8

RE: Formaldehyde Sampling
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Attached please find our Air Sample Log.

Yours truly,

JOHN MACRAE & ASSOCIATES INC.

John MacRae

JM/ab

100 -1144 FORT ST.
VICTORIA, B.C.
CANADA V8V 3K8
Telephone (604) 380-3911
Cellular (604) 727-1123
Fax (604) 380-1123

AIR SAMPLE LOG

John McRae & Associates, Inc.

PROJECT: Housing Project, Jacklin Road

DATE	START TIME	READOUT TIME	TOTAL MINUTES	COUNT	FLOW RATE	VOL./AIR (LITRES)	LOCATION	TYPE	SAMPLE #	SAMPLE CONCENTRATION ug/L	AIRBORNE CONCENTRATION
93 04 02	12:16	12:38	22	N/ap	1.0	22	Suite #5	Area	1	<0.01	<0.1 ppm
93 04 02	12:21	12:41	20	N/ap	1.0	20	Suite #[illegible]	Area	2	<0.01	<0.1 ppm
93 04 02	Blank	-	-	-	-	-	-	Blank	3	<0.01	Blank

All samples less than quantification limit.

APPENDIX 9.

MYCOLOGICAL TEST RESULTS

MYCOLOGICAL TESTING

The mycological - biological tests were performed using three types of media to ensure a full collection of fungi present in the environment. The media used are described in the microbiological analysis included in this Appendix. Petri dishes were placed in each home environment for a period of half an hour. The Mycological Testing Results list the organisms identified in each of the samples. The results indicate that no alarming human pathogens exist in any of the samples.

MYCOLOGICAL DEFINITIONS

BACTERIA - Minute, unicellular organisms that exist on dead organic matter or as parasites. Bacteria are the chief agents of fermentation, putrefication and decay. Many are capable of producing disease or pathogenic.

FUNGUS - Any of a large group of simple plants characterized by a lack of chlorophyll, such as molds, mildews, mushrooms, rusts, and smuts. Most have a filamentous body or mycelium and subsist on dead organic matter or as parasites.

YEASTS - A semi-fluid substance consisting principally of the unicellular fungi which forms on the surface or as a sediment in fermented fruit juices; is used in inducing alcoholic fermentation; or in the production of medicine.

MB RESEARCH

ANALYTICAL & TESTING SERVICES

Attn : Mary Paryniuk
Client: K.I.R.
Sample: M2215

Sample	Numbers per Plate	Organisms Identified	Likely Habitat/Comments
L-1 (Langford)	2×10^2	Curtobacterium flaccumfaciens	bacteria; soil
	4	Rhizopus sp	fungus; airborne, soil
	40	Penicillium simplicissimum	fungus; airborne, soil
	4	Penicillium glabrum	fungus; soil, vegetation
	1	Aureobasidium pullulans	fungus; soil, vegetation
	8	Bacillus coagulans	bacteria; soil, vegetation
	3	Staphylococcus warneri	bacteria; skin, environmental
	1×10^2	Arthrobacter siderocapsulatus	bacteria; soil
	1×10^2	Staphylococcus haemolyticus	bacteria; skin, environmental
L-2 (Langford)	1	Penicillium simplicissimum	fungus; airborne, soil
	1	Penicillium glabrum	fungus; soil, vegetation
L-3 (Langford)	1	Penicillium simplicissimum	fungus; airborne, soil
	2	Penicillium glabrum	fungus; soil, vegetation
	1×10^2	Staphylococcus hyicus subsp hyicus	bacteria; animal skin; animal pathogen
L-4 (Langford)	1×10^2	Sarcina sp	bacteria; soil
	1×10^2	Enterobacter agglomerans	bacteria; soil, water, vegetation, sewage
	4×10^2	Staphylococcus haemolyticus	bacteria; skin, environmental
P-1	1×10^2	Sarcina sp	bacteria; soil
	1×10^2	Brevibacterium frigoritolerans	bacteria; soil
	2×10^2	Staphylococcus haemolyticus	bacteria; skin, environmental
P-2	1×10^2	Sarcina sp	bacteria; soil
	1×10^2	Staphylococcus haemolyticus	bacteria; skin, environmental
	1×10^2	Arthrobacter ml siderocapsulatus	bacteria; soil
	1×10^2	Staphylococcus xylosus	bacteria; skin, environmental
P-3	28	Penicillium simplicissimum	fungus; airborne, soil
	3	Penicillium sp	fungus; airborne, soil
	1×10^2	Sarcina sp	bacteria; soil
	4×10^2	Arthrobacter siderocapsulatus	bacteria; soil
	3×10^2	Staphylococcus haemolyticus	bacteria; skin, environmental
	1×10^2	Enterobacter agglomerans	bacteria; soil, water, vegetation, sewage
	1×10^2	Curtobacterium flaccumfaciens	bacteria; soil
	2×10^2	Arthrobacter ml siderocapsulatus	bacteria; soil

Microbiologist

MB RESEARCH

ANALYTICAL & TESTING SERVICES

Client: Environmental Investigations Research Ltd.
Sample: W1888

Sample	Numbers per Plate	Organisms Identified	Likely Habitat/Comments
#8	3	Bacillus coagulans	bacteria, soil
	1	Trichoderma sp	fungus, airborne, soil
	1	Penicillium simplicissimum	fungus, airborne, soil
	1	Candida sp	yeast, soil, environmental
	1	Hyalodendron pirinum	fungus, soil
	10	Staphylococcus warneri	bacteria, skin, environmental
	7	Staphylococcus hominis	bacteria, primarily human skin
	1	Staphylococcus saprophyticus	bacteria, skin, environmental
	2	Phoma sp	fungus, soil, vegetation
	1	Trichoderma sp	fungus, airborne, soil
#3	4	Penicillium sp	fungus, airborne, soil
	3	Staphylococcus warneri	bacteria, skin, environmental
	3	Curtobacterium flaccumfaciens	bacteria, vegetation; plant pathogen
	1	Curtobacterium albidum	bacteria, soil, vegetation
	1	Trichoderma sp	fungus, airborne, soil
#4	1	Rhodotorula rubra	yeast, airborne, seasonal
	2	Staphylococcus warneri	bacteria, skin, environmental
	1	Staphylococcus saprophyticus	bacteria, skin, environmental
	4	Aerococcus sp	bacteria, common airborne
	5	Staphylococcus haemolyticus	bacteria, skin, environmental
	3	Williopsis saturnus	yeast, soil
#6	2	Penicillium simplicissimum	fungus, airborne, soil
	1	Penicillium chrysogenum	fungus, soil, vegetation
	2	Staphylococcus haemolyticus	bacteria, skin, environmental
Hector	10	Penicillium simplicissimum	fungus, airborne, soil
	5	Penicillium glabrum	fungus, soil, vegetation
	1	Trichoderma ml viridae	fungus, soil
	2	Penicillium sp	fungus, airborne, soil
	1	Aspergillus sp	fungus, soil
	6	Staphylococcus xylosus	bacteria, skin, environmental
	1	Arthrobacter ml citreus	bacteria, soil, dust
	1	Klebsiella ml planticola	bacteria, soil, water, vegetation
#5	1	Penicillium ml glabrum	fungus, soil, vegetation
	1	Staphylococcus warneri	bacteria, skin, environmental
	1	Staphylococcus auricularis	bacteria, skin, ear
	1	Streptomyces sp	bacteria, airborne, soil
	1	Kurthia zopfii	bacteria, soil & surface water

H. Hartman
Microbiologist

MB RESEARCH & DEVELOPMENT LTD. P.O. BOX 2103, SIDNEY, B.C. V8L 3S6 TEL: (604) 656-1334

MB RESEARCH
ANALYTICAL & TESTING SERVICES

Client: E.I.R. Ltd./ Mary Parynuik
Sample: #W1888

MEDIA USED FOR SAMPLING:

1. BAP — tryptone soya broth (soybean-casein digest U.S.P.) Oxoid CM129
   0.5% (wt:vol) sodium chloride
   5.0% human blood (outdated)
   1.5% agar

2. WA — 1.5% water agar

3. PDA — potato dextrose broth Difco
   1.5% agar

MB RESEARCH & DEVELOPMENT LTD. P.O. BOX 2103, SIDNEY, B.C. V8L 3S6 TEL: (604) 656-1334

APPENDIX 10.

OCCUPANTS AND BUILDER

QUESTIONNAIRES

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Address: # 3 JACKLIN ROAD

Type of air handling system AERECO

1. Type and size of home ATTACHED 1½ SIDES
2. Type of insulation R 20 WALLS R34 ATTIC
3. Number of occupants living in the home? 3
4. Generally speaking how much time do you spend in your home in a 24 hour time period?

~ 18 hours

In general, on a scale from 1 being the worst to 5 being the best, please rank the following with respect to: (please note any additional comments)

5. Temperature 3
6. Drafts 4
7. Ventilation 3
8. Air freshness 4
9. Air movement 4
10. Odors 4
11. Humidity 5
12. Dust 0 have to dust every other day
13. Molds 5

TOTAL

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Please answer the following questions with a YES or a NO

14. Does anyone smoke in this home? If so how often?

yes ~ 4 cigarettes /nite

15. Does anyone living in this home have allergies? If so, what are they?

none

16. Do you use your kitchen fan? If so, how often?

yes all the time

17. Do you use your bathroom fan? If so, how often?

no fan

18. Do you open your windows? If so, how often?

yes 1st thing in the morning

NIGHT? no 30 - 45 min/day open

Do you generally have problems with any of the following:

16. Colds no
17. Coughing no
18. Sore throats no
19. Faintness no
20. Nausea no
21. Fatigue no
22. Headaches no
23. Back pain no
24. Eye strain no
25. Watery eyes no

- initially for the first week & then it dissipated

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

26. Skin irritation __no__________________________________

27. What cleaning products do you use in your home and how often?
__Mr. Clean, comet, ~every other day Lemon pledge / 1X/week__

28. What type of vacuum cleaner do you use and how often?
__none yet, use a broom now every other__

29. What is the most significant factor affecting the air quality in your home?
__dusty__________________________________
____

30. What are the two or three aspects of living in this home that you would like to change or see changed?
__need some bathroom fans →______________
__but it doesn't get steamy → they open__
__the window ~1"__________________________

31. What two or three features of this home do you enjoy the most?
__lots of space___________________________
__quiet___________________________________
__good heat distribution__________________

THANK YOU FOR YOUR COOPERATION, PLEASE ADD ANY ADDITIONAL COMMENTS

sliding door gets jammed *tell Patti

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Address: # 4 JACKLIN RD

Type of air handling system BC CODE (two W/R FANS) .3 DH .15 CONT

1. Type and size of home ATTACHED 2 SIDES
2. Type of insulation R-20 WALL R34 CLG
3. Number of occupants living in the home? 1 ADULT 2 KIDS
4. Generally speaking how much time do you spend in your home in a 24 hour time period?

   WEEKDAY 15 hr ; WEEKEND 10 HR

In general, on a scale from 1 being the worst to 5 being the best, please rank the following with respect to:
(please note any additional comments)

5. Temperature 2 need all 'stats to keep warm
6. Drafts 2 DRAFTY UPSTAIRS
7. Ventilation 5
8. Air freshness 5
9. Air movement 5
10. Odors 4
11. Humidity 3 UPSTAIRS
12. Dust 4
13. Molds 5

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Please answer the following questions with a YES or a NO

14. Does anyone smoke in this home? If so how often?

YES SELDOM

15. Does anyone living in this home have allergies? If so, what are they?

No

16. Do you use your kitchen fan? If so, how often?

YES ALWAYS WHEN COOKING

17. Do you use your bathroom fan? If so, how often?

No

18. Do you open your windows? If so, how often?

YES SATURDAYS
NOT AT NIGHT

Do you generally have problems with any of the following:

16. Colds ___ YES (kids constantly) ___
17. Coughing ___ YES " " ___
18. Sore throats ___ No ___
19. Faintness ___ No ___
20. Nausea ___ SOMEWHAT ___
21. Fatigue ___ No ___
22. Headaches ___ YES ___
23. Back pain ___ No ___
24. Eye strain ___ No ___
25. Watery eyes ___ No ___

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

26. Skin irritation No

27. What cleaning products do you use in your home and how often?

COMET 3X/WK

28. What type of vacuum cleaner do you use and how often?

UPRIGHT 2-3/WK

29. What is the most significant factor affecting the air quality in your home?

OCCASIONAL STALE AIR - NEED WINDOWS,

30. What are the two or three aspects of living in this home that you would like to change or see changed?

NOTHING

31. What two or three features of this home do you enjoy the most?

WARMER THAN PREVIOUS HOUSE

SPACIOUS

THANK YOU FOR YOUR COOPERATION, PLEASE ADD ANY ADDITIONAL COMMENTS

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Address: #5 JACKLIN RD

Type of air handling system NEG. PR / WALL PIPE MAKE-UP

1. Type and size of home ATTACHED 2-SIDES
2. Type of insulation R-20 WALLS / R-34 ATTIC
3. Number of occupants living in the home? 2 ADULTS / 2 KIDS
4. Generally speaking how much time do you spend in your home in a 24 hour time period?

   24 hr

In general, on a scale from 1 being the worst to 5 being the best, please rank the following with respect to:
(please note any additional comments)

5. Temperature 5
6. Drafts 5
7. Ventilation 4
8. Air freshness 4
9. Air movement 4
10. Odors 4
11. Humidity 4 SWEATS UP SOMETIMES
12. Dust 5
13. Molds 5

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Please answer the following questions with a YES or a NO

14. **Does anyone smoke in this home? If so how often?**

    YES ______ EVERY DAY ____________________

15. **Does anyone living in this home have allergies? If so, what are they?**

    NO ____________________________________

16. **Do you use your kitchen fan? If so, how often?**

    ½ TIME ________________________________

17. **Do you use your bathroom fan? If so, how often?**

    NO FAN CONTROL ________________________

18. **Do you open your windows? If so, how often?**

    NO ____________________________________

    NIGHT ___NO_______

Do you generally have problems with any of the following:

16. **Colds** ____NO____________________
17. **Coughing** ____NO____________________
18. **Sore throats** ____NO____________________
19. **Faintness** ____NO____________________
20. **Nausea** ____NO____________________
21. **Fatigue** ____NO____________________
22. **Headaches** ____NO____________________
23. **Back pain** ____NO____________________
24. **Eye strain** ____NO____________________
25. **Watery eyes** ____NO____________________

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

26. Skin irritation No

27. What cleaning products do you use in your home and how often?

COMET WINDEX SPIC$SPAN

28. What type of vacuum cleaner do you use and how often?

PORT A POWER (hoover)

29. What is the most significant factor affecting the air quality in your home?

SMOKE

30. What are the two or three aspects of living in this home that you would like to change or see changed?

MORE STORAGE

31. What two or three features of this home do you enjoy the most?

2 BATHRMS

THANK YOU FOR YOUR COOPERATION, PLEASE ADD ANY ADDITIONAL COMMENTS

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Address: #6 JACKLIN

Type of air handling system NEG. PR. / HI SIDEWALL MAKE-UP

1. Type and size of home ATTACHED 1 SIDE

2. Type of insulation R-20 WALLS / R-34 ATTICS

3. Number of occupants living in the home? 1 ADULT 1 KID

4. Generally speaking how much time do you spend in your home in a 24 hour time period?

   21 hR week 21 hr weekend

In general, on a scale from 1 being the worst to 5 being the best, please rank the following with respect to:
(please note any additional comments)

5. Temperature 1

6. Drafts 1

7. Ventilation 4

8. Air freshness 4

9. Air movement 4

10. Odors 4 paint at first - ok now

11. Humidity 2

12. Dust 4

13. Molds 4

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Please answer the following questions with a YES or a NO

14. Does anyone smoke in this home? If so how often?

3 CIGS / DAY

15. Does anyone living in this home have allergies? If so, what are they?

No

16. Do you use your kitchen fan? If so, how often?

Y all the time

17. Do you use your bathroom fan? If so, how often?

Y all the time (central?)

18. Do you open your windows? If so, how often?

SELDOM

NIGHT: NO

Do you generally have problems with any of the following:

16. Colds N
17. Coughing N
18. Sore throats Y
19. Faintness N
20. Nausea N
21. Fatigue N
22. Headaches N
23. Back pain N
24. Eye strain Y bathroom too bright
25. Watery eyes N

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

26. Skin irritation N

27. What cleaning products do you use in your home and how often?

MR CLEAN / AJAX / IVORY DISH 1/WK

28. What type of vacuum cleaner do you use and how often?

NONE PORTABLE

29. What is the most significant factor affecting the air quality in your home?

SMOKING

30. What are the two or three aspects of living in this home that you would like to change or see changed?

NOTHING

31. What two or three features of this home do you enjoy the most?

KITCHEN

SPACIOUS

THANK YOU FOR YOUR COOPERATION, PLEASE ADD ANY ADDITIONAL COMMENTS

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Address: #8 JACKLIN RD

Type of air handling system HRV

1. Type and size of home ATTACHED 2 SIDES
2. Type of insulation R-20 WALLS / R-34 ATTICS
3. Number of occupants living in the home? 5
4. Generally speaking how much time do you spend in your home in a 24 hour time period?

   ~ 12 hours

In general, on a scale from 1 being the worst to 5 being the best, please rank the following with respect to:
(please note any additional comments)

5. Temperature 5
6. Drafts 5 drofty in the storage room
7. Ventilation 5
8. Air freshness 5
9. Air movement 5
10. Odors not noticeable 4
11. Humidity 5
12. Dust 4
13. Molds none 5

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Please answer the following questions with a YES or a NO

14. Does anyone smoke in this home? If so how often?

no

15. Does anyone living in this home have allergies? If so, what are they?

3 boys 13, 12, 2 yrs old dust mildew cats & dogs ?carpet
12 & 13 yr old have had nose bleeds
12yrs old br out in hives (some food.

16. Do you use your kitchen fan? If so, how often?

yes every time she cooks

17. Do you use your bathroom fan? If so, how often?

no bathroom fan

18. Do you open your windows? If so, how often?

yes every evening sometimes Bathroom when cleaning
Night M. bedroom window open at night

Do you generally have problems with any of the following:

16. Colds just the boys with allergies

17. Coughing " " " " "

18. Sore throats " " " " "

19. Faintness just the 12 yr old some 13 yr old

20. Nausea no

21. Fatigue " " " " " ?

22. Headaches 12 & 13 yr old

23. Back pain yes

24. Eye strain no

25. Watery eyes no

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

26. Skin irritation just the 12yr old

27. What cleaning products do you use in your home and how often?

Mr. Clean, lysol every week

28. What type of vacuum cleaner do you use and how often?

electrolux 2100 1 every 2nd day

29. What is the most significant factor affecting the air quality in your home?

no

30. What are the two or three aspects of living in this home that you would like to change or see changed?

fans in the bathroom

31. What two or three features of this home do you enjoy the most?

comfortable, soothing colors, plenty of light

The kids are very happy

THANK YOU FOR YOUR COOPERATION. PLEASE ADD ANY ADDITIONAL COMMENTS

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Address: 395 Hector Road Sharon & Dave Metcalf
Victoria
2 months

Type of air handling system Negative Pressure Crawl Space / Pos Pr

1. Type and size of home 2400 ft^2

2. Type of insulation fiberglass pink

3. Number of occupants living in the home? 4

4. Generally speaking how much time do you spend in your home in a 24 hour time period?

   17 hours

In general, on a scale from 1 being the worst to 5 being the best, please rank the following with respect to:
(please note any additional comments)

5. Temperature 4

6. Drafts 4

7. Ventilation 5

8. Air freshness 4

9. Air movement 3

10. Odors 4

11. Humidity 4

12. Dust 3+

13. Molds none, new home

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Please answer the following questions with a YES or a NO

14. Does anyone smoke in this home? If so how often?
    yes every day, all day

15. Does anyone living in this home have allergies? If so, what are they?
    none

16. Do you use your kitchen fan? If so, how often?
    yes, whever she cook

17. Do you use your bathroom fan? If so, how often?
    yes, showering in the morning always

18. Do you open your windows? If so, how often?
    no, not in the ~~windo~~ winter, summers only

Do you generally have problems with any of the following:

16. Colds no
17. Coughing no
18. Sore throats no
19. Faintness no
20. Nausea no
21. Fatigue no
22. Headaches no
23. Back pain no
24. Eye strain no
25. Watery eyes no

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

26. Skin irritation no

27. What cleaning products do you use in your home and how often?

windex, Mr. Clean, Foam-tub&tile cleaner 1X/week and touch up thru the week

28. What type of vacuum cleaner do you use and how often?

Built in, electrolux

29. What is the most significant factor affecting the air quality in your home?

none

30. What are the two or three aspects of living in this home that you would like to change or see changed?

none

31. What two or three features of this home do you enjoy the most?

She is happy with everything (more or less)
no comment

THANK YOU FOR YOUR COOPERATION, PLEASE ADD ANY ADDITIONAL COMMENTS

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Address: Gail & Mike Pichichero
2829 Pickford Road
Vic. B.C. V9B 2K3 478-0020

Type of air handling system baseboard heaters

1. Type and size of home ~~X~~ Split level 2 floor

2. Type of insulation
Builder David

3. Number of occupants living in the home? 2

4. Generally speaking how much time do you spend in your home in a 24 hour time period?

~ 22 hours / Mike ~ 12 hrs

In general, on a scale from 1 being the worst to 5 being the best, please rank the following with respect to:
(please note any additional comments)

5. Temperature 3

6. Drafts 3

7. Ventilation 4

8. Air freshness 4

9. Air movement 4

10. Odors 4

11. Humidity 1

12. Dust 3

13. Molds 1

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

Please answer the following questions with a YES or a NO

14. Does anyone smoke in this home? If so how often?

    no

15. Does anyone living in this home have allergies? If so, what are they?

    no

16. Do you use your kitchen fan? If so, how often?

    not much (the exhaust doesn't go outside.

17. Do you use your bathroom fan? If so, how often?

    yes, always

18. Do you open your windows? If so, how often?

    not in the winter

Do you generally have problems with any of the following:

16. Colds no
17. Coughing no
18. Sore throats no
19. Faintness no
20. Nausea no
21. Fatigue no
22. Headaches no
23. Back pain no
24. Eye strain no
25. Watery eyes no

HOMEOWNERS INDOOR AIR QUALITY QUESTIONNAIRE

26. Skin irritation __no______________________________

27. What cleaning products do you use in your home and how often?

pine sol / ajax / Mr. Clean ____ 1x/week ____

28. What type of vacuum cleaner do you use and how often?

Hoover upright ____ 1X per 1½ months ____

29. What is the most significant factor affecting the air quality in your home?

humidity → mold in windows sills ____

lack of ventilation in the kitchen re: cooking odors

30. What are the two or three aspects of living in this home that you would like to change or see changed?

solve the mold problem / humidity probl

drafty at the front door entrance → design pr

____

31. What two or three features of this home do you enjoy the most?

light / brightness / spacious / has a basement

crawlspace for storage ____________________

____

THANK YOU FOR YOUR COOPERATION, PLEASE ADD ANY ADDITIONAL COMMENTS

HELENA

MIN CODE
APR. '90

Air Quality Questionnaire

Thank you for helping out with our air quality study. You were great, and I think we've learned some good things about the different kinds of ventilation systems.

As part of the study, we'd like to ask how you've found the comfort of your house in the last couple of weeks. If you haven't noticed any difference from day to day, then that's useful information too.

	MARCH 22 - 29 th	MARCH 30 - APR 6 th
TOO COLD		
TOO HOT		
TOO STUFFY		
TOO DRAFTY		
TOO MOIST		

If you kept your windows closed, did it make the living area less comfortable? Yes How about the bedroom? yes

How many people lived in the house during the survey? 3

Were you away at all during the survey? Yes. If you can remember when, please write dates down.

Away March 22, 23, 24, 31
April 6, 7, 8, 9

Most of the time I had to open windows upstairs & downstairs & back door to get fresh air. It's often too stuffy, too hot. Not drafty, not cold except in both bathrooms. Its not too moist.

Thanks BS

CINDY & TRACY

WALL PIPE

Air Quality Questionnaire

Thank you for helping out with our air quality study. You were great, and I think we've learned some good things about the different kinds of ventilation systems.

As part of the study, we'd like to ask how you've found the comfort of your house in the last couple of weeks. If you haven't noticed any difference from day to day, then that's useful information too.

	MARCH 22 - 29 th	MARCH 30 - APR 6 th
TOO COLD		
TOO HOT		
TOO STUFFY		
TOO DRAFTY		
TOO MOIST		

If you kept your windows closed, did it make the living area less comfortable?________ How about the bedroom?________

How many people lived in the house during the survey?_3____

Were you away at all during the survey?_yes_. If you can remember when, please write dates down.

about two days. march.

Thanks,

WALL INLET
APR. 90

Air Quality Questionnaire

Thank you for helping out with our air quality study. You were great, and I think we've learned some good things about the different kinds of ventilation systems.

As part of the study, we'd like to ask how you've found the comfort of your house in the last couple of weeks. If you haven't noticed any difference from day to day, then that's useful information too.

	MARCH 22 - 29 th	MARCH 30 - APR 6 th
TOO COLD		
TOO HOT		
TOO STUFFY	✓	✓
TOO DRAFTY		
TOO MOIST		

If you kept your windows closed, did it make the living area less comfortable? yes How about the bedroom? SOMETIME

How many people lived in the house during the survey? [2]

Were you away at all during the survey? ~~yes~~ NO. If you can remember when, please write dates down.

Henry and I didn't find no change but when the windows were shut, it get stuffy in the rooms.

Thanks, [signature]

VENTILATION QUESTIONNAIRE

	B.C. CODE VENTILATION		H.R.V. FULL DUCT SYSTEM	
	YES	NO	YES	NO
1) Does it meet air quality needs?	✓			
2) Does it effectively deal with:				
a) Moisture?	✓			
b) Odors?	✓			
c) Contaminants?	✓			
3) Is it: a) Excessive?	[illegible]		[illegible]	
b) Necessary?				

4) Approximately how much does it cost to install B.C. Code Ventilation in an electric baseboard house with three bathrooms?

$ 1200

5) Approximately how much does it cost to install an HRV Full Duct System in an electric baseboard house with three bathrooms?

$ 1200

6) There is a proposal that the 1995 Building Code will require a fully ducted, continuous ventilation system. Considering the increases in the air tightness of construction, do you think this proposal is:

a) Necessary? ✓

b) Unnecessary? ____

Comments ____

MARKETABILITY OF VENTILATION SYSTEMS

	Easy to Market						Difficult to Market
B.C. Code System	3	(2)	1	0	1	2	3
HRV System	3	(2)	1	0	1	2	3

MAINTENANCE OF VENTILATION SYSTEMS

	Easy to Maintain						Difficult to Maintain
B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

AIR QUALITY EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

POLLUTION CONTROL EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

INSTALLATION OF VENTILATION SYSTEMS

	Easy to Install						Difficult to Install
B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

VENTILATION QUESTIONNAIRE

	B.C. CODE VENTILATION YES	B.C. CODE VENTILATION NO	H.R.V. FULL DUCT SYSTEM YES	H.R.V. FULL DUCT SYSTEM NO
1) Does it meet air quality needs?		✓	✓	
2) Does it effectively deal with:				
a) Moisture?		✓	✓	
b) Odors?		✓	✓	
c) Contaminants?		✓	✓	
3) Is it: a) Excessive?				
b) Necessary?	✓		✓	

4) Approximately how much does it cost to install B.C. Code Ventilation in an electric baseboard house with three bathrooms?

$ ~~$[illegible]~~ – ~~$[illegible]~~ $500

5) Approximately how much does it cost to install an HRV Full Duct System in an electric baseboard house with three bathrooms?

$ $1800

6) There is a proposal that the 1995 Building Code will require a fully ducted, continuous ventilation system. Considering the increases in the air tightness of construction, do you think this proposal is:

a) Necessary? ✓

b) Unnecessary? ______

Comments: It is a good way to control the living quality within the home

MARKETABILITY OF VENTILATION SYSTEMS

	Easy to Market						Difficult to Market
B.C. Code System	(3) circled	2	1	0	1	2	3
HRV System	3	(2) circled	1	0	1	2	3

MAINTENANCE OF VENTILATION SYSTEMS

	Easy to Maintain						Difficult to Maintain
B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

AIR QUALITY EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

POLLUTION CONTROL EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

INSTALLATION OF VENTILATION SYSTEMS

	Easy to Install						Difficult to Install
B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

VENTILATION QUESTIONNAIRE

	B.C. CODE VENTILATION		H.R.V. FULL DUCT SYSTEM	
	YES	NO (circled)	YES (circled)	NO
1) Does it meet air quality needs?	H.R.V. yes			

2) Does it effectively deal with:

(a) (circled) Moisture?

(b) (circled) Odors?

(c) (circled) Contaminants?

3) Is it: a) Excessive?

(b) (circled) Necessary?

4) Approximately how much does it cost to install B.C. Code Ventilation in an electric baseboard house with three bathrooms?

$ 1,500.00 + tax depends on size of house

5) Approximately how much does it cost to install an HRV Full Duct System in an electric baseboard house with three bathrooms?

$ 2,000.00 + tax depends on size of house

6) There is a proposal that the 1995 Building Code will require a fully ducted, continuous ventilation system. Considering the increases in the air tightness of construction, do you think this proposal is:

(a) (circled) Necessary? yes

b) Unnecessary? ____

Comments: Until you live in a fully ventilated house, you don't know what you're missing

MARKETABILITY OF VENTILATION SYSTEMS

	Easy to Market						Difficult to Market
B.C. Code System	3 (circled)	2	1	0	1	2	3
HRV System	3 (circled)	2	1	0	1	2	3

Price counts more than ever before rather than quality

1st time buyer - cheap; better, bigger houses

MAINTENANCE OF VENTILATION SYSTEMS

	Easy to Maintain						Difficult to Maintain	
B.C. Code System	3	2	1	0	(1)	2	3	cold draft
HRV System	(3)	2	1	0	1	2	3	clean filters

AIR QUALITY EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	(3)	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	(3)

POLLUTION CONTROL EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	(3)	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	(3)

INSTALLATION OF VENTILATION SYSTEMS

	Easy to Install						Difficult to Install
B.C. Code System	(3)	2	1	0	1	2	3
HRV System	(3)	2	1	0	1	2	3

VENTILATION QUESTIONNAIRE

	B.C. CODE VENTILATION		H.R.V. FULL DUCT SYSTEM	
	YES	NO	YES	NO
1) Does it meet air quality needs?		✗	✓	
2) Does it effectively deal with:				
a) Moisture?		✗	✓	
b) Odors?		✗	✓	
c) Contaminants?		✗	✓	
3) Is it: a) Excessive?		✗		✓
b) Necessary?			✓	

4) Approximately how much does it cost to install B.C. Code Ventilation in an electric baseboard house with three bathrooms?

$ 400-500

5) Approximately how much does it cost to install an HRV Full Duct System in an electric baseboard house with three bathrooms?

$ 1300 to 1500

6) There is a proposal that the 1995 Building Code will require a fully ducted, continuous ventilation system. Considering the increases in the air tightness of construction, do you think this proposal is:

a) Necessary? ✓

b) Unnecessary? ____________

Comments ____________________

MARKETABILITY OF VENTILATION SYSTEMS

	Easy to Market						Difficult to Market
B.C. Code System	3	2	1	0	1	(2)	3
HRV System	3	2	(1)	0	1	2	3

MAINTENANCE OF VENTILATION SYSTEMS

	Easy to Maintain						Difficult to Maintain
B.C. Code System	3	**2**	1	0	1	2	3
HRV System	3	2	1	**0**	1	2	3

AIR QUALITY EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	**3**	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	**3**

POLLUTION CONTROL EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	**3**	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	**3**

INSTALLATION OF VENTILATION SYSTEMS

	Easy to Install						Difficult to Install
B.C. Code System	3	2	1	0	1	**2**	3
HRV System	3	2	1	0	**1**	2	3

VENTILATION QUESTIONNAIRE

	B.C. CODE VENTILATION YES	B.C. CODE VENTILATION NO	H.R.V. FULL DUCT SYSTEM YES	H.R.V. FULL DUCT SYSTEM NO
1) Does it meet air quality needs?		NO	YES	
2) Does it effectively deal with:				
a) Moisture?		NO	YES	
b) Odors?		NO	YES	
c) Contaminants?		NO	YES	
3) Is it: a) Excessive?		NO		NO
b) Necessary?	YES		YES	

4) Approximately how much does it cost to install B.C. Code Ventilation in an electric baseboard house with three bathrooms?

$ 450

5) Approximately how much does it cost to install an HRV Full Duct System in an electric baseboard house with three bathrooms?

$ 2000

6) There is a proposal that the 1995 Building Code will require a fully ducted, continuous ventilation system. Considering the increases in the air tightness of construction, do you think this proposal is:

a) Necessary? ✓

b) Unnecessary? ________

Comments ____________________

MARKETABILITY OF VENTILATION SYSTEMS

	Easy to Market						Difficult to Market
B.C. Code System	3	2	(1) circled	0	1	2	3
HRV System	3	(2) circled	1	0	1	2	3

MAINTENANCE OF VENTILATION SYSTEMS

	Easy to Maintain						Difficult to Maintain
B.C. Code System	**3**	2	1	0	1	2	3
HRV System	3	2	1	0	**1**	2	3

AIR QUALITY EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	**2**	1	0	1	2	3
HRV System	3	2	1	0	1	2	**3**

POLLUTION CONTROL EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	2	**1**	0	1	2	3
HRV System	3	2	1	**0**	1	2	3

INSTALLATION OF VENTILATION SYSTEMS

	Easy to Install						Difficult to Install
B.C. Code System	**3**	2	1	0	1	2	3
HRV System	3	2	1	0	1	**2**	3

VENTILATION QUESTIONNAIRE

	B.C. CODE VENTILATION		H.R.V. FULL DUCT SYSTEM	
	(YES) circled	NO	YES	(NO) circled

1) Does it meet air quality needs? YES B.C CODE

2) Does it effectively deal with:

a) Moisture? YES B.C CODE

b) Odors?

c) Contaminants?

3) Is it: a) Excessive? NO B.C CODE

b) Necessary?

4) Approximately how much does it cost to install B.C. Code Ventilation in an electric baseboard house with three bathrooms?

$ 250.00

5) Approximately how much does it cost to install an HRV Full Duct System in an electric baseboard house with three bathrooms?

$ 1800.00

6) There is a proposal that the 1995 Building Code will require a fully ducted, continuous ventilation system. Considering the increases in the air tightness of construction, do you think this proposal is:

a) Necessary? ________

b) Unnecessary? ✓

Comments____________________

MARKETABILITY OF VENTILATION SYSTEMS

	Easy to Market						Difficult to Market
B.C. Code System	(3) circled	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

MAINTENANCE OF VENTILATION SYSTEMS

	Easy to Maintain						Difficult to Maintain
B.C. Code System	3 [circled]	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

AIR QUALITY EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	2	1	0 [circled]	1	2	3
HRV System	3	2	1	0	1	2	3

POLLUTION CONTROL EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	2	1	0 [circled]	1	2	3
HRV System	3	2	1	0	1	2	3

INSTALLATION OF VENTILATION SYSTEMS

	Easy to Install						Difficult to Install
B.C. Code System	3 [circled]	2	1	0	1	2	3
HRV System	3 [circled]	2	1	0	1	2	3

VENTILATION QUESTIONNAIRE

	B.C. CODE VENTILATION YES	B.C. CODE VENTILATION NO	H.R.V. FULL DUCT SYSTEM YES	H.R.V. FULL DUCT SYSTEM NO
	(YES) circled	NO	(YES) circled	NO
1) Does it meet air quality needs?				
2) Does it effectively deal with:				
a) Moisture?	✓			
b) Odors?	✓			
c) Contaminants?	✓			
3) Is it: a) Excessive?			✓	
b) Necessary?				✓

4) Approximately how much does it cost to install B.C. Code Ventilation in an electric baseboard house with three bathrooms?

$ ______ $175.00 ______

5) Approximately how much does it cost to install an HRV Full Duct System in an electric baseboard house with three bathrooms?

$ ______ $2200.00 ______

6) There is a proposal that the 1995 Building Code will require a fully ducted, continuous ventilation system. Considering the increases in the air tightness of construction, do you think this proposal is:

a) Necessary? ________

b) Unnecessary? YES.

Comments FOR THE COAST IT IS NOT NECESSARY.

MARKETABILITY OF VENTILATION SYSTEMS

	Easy to Market						Difficult to Market
B.C. Code System	3	(2) circled	1	0	1	2	3
HRV System	3	2	1	0	(1) circled	2	3

MAINTENANCE OF VENTILATION SYSTEMS

	Easy to Maintain						Difficult to Maintain
B.C. Code System	(3)	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	(3)

AIR QUALITY EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	(2)	1	0	1	2	3
HRV System	3	2	1	0	(1)	2	3

POLLUTION CONTROL EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	(2)	1	0	1	2	3
HRV System	3	2	(1)	0	1	2	3

INSTALLATION OF VENTILATION SYSTEMS

	Easy to Install						Difficult to Install
B.C. Code System	(3)	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	(3)

13 = ? %

60 builder members

727 8803

VENTILATION QUESTIONNAIRE

	B.C. CODE VENTILATION YES	B.C. CODE VENTILATION NO	H.R.V. FULL DUCT SYSTEM YES	H.R.V. FULL DUCT SYSTEM NO
1) Does it meet air quality needs?	✓ (YES circled)			
2) Does it effectively deal with:	✓			
a) Moisture?	✓			
b) Odors?	✓			
c) Contaminants?	✓			
3) Is it: a) Excessive?	[illegible]		✓	
b) Necessary?	✓			

4) Approximately how much does it cost to install B.C. Code Ventilation in an electric baseboard house with three bathrooms?

$ $190.00

5) Approximately how much does it cost to install an HRV Full Duct System in an electric baseboard house with three bathrooms?

$ $2000.00

6) There is a proposal that the 1995 Building Code will require a fully ducted, continuous ventilation system. Considering the increases in the air tightness of construction, do you think this proposal is:

a) Necessary? ______

b) Unnecessary? ✓

Comments: to much garbage in code all ready

MARKETABILITY OF VENTILATION SYSTEMS

	3 (Easy to Market)	2	1	0	1	2	3 (Difficult to Market)
B.C. Code System	✓						
HRV System							✓

MAINTENANCE OF VENTILATION SYSTEMS

Easy to Maintain ← → Difficult to Maintain

	3	2	1	0	1	2	3
B.C. Code System	✓						
HRV System							✓

AIR QUALITY EFFECTIVENESS OF VENTILATION SYSTEMS

Not Very Effective ← → Very Effective

	3	2	1	0	1	2	3
B.C. Code System							✓
HRV System	✓						

POLLUTION CONTROL EFFECTIVENESS OF VENTILATION SYSTEMS

Not Very Effective ← → Very Effective

	3	2	1	0	1	2	3
B.C. Code System							✓
HRV System	✓						

INSTALLATION OF VENTILATION SYSTEMS

Easy to Install ← → Difficult to Install

	3	2	1	0	1	2	3
B.C. Code System	✓						
HRV System							✓

VENTILATION QUESTIONNAIRE

	B.C. CODE VENTILATION		H.R.V. FULL DUCT SYSTEM	
	YES (circled)	NO	YES	NO
1) Does it meet air quality needs?				
2) Does it effectively deal with:				
a) Moisture?				
b) Odors?				
c) Contaminants?				
3) Is it: a) Excessive?				
b) Necessary?				

4) Approximately how much does it cost to install B.C. Code Ventilation in an electric baseboard house with three bathrooms?

$ I Do not use [illegible]

5) Approximately how much does it cost to install an HRV Full Duct System in an electric baseboard house with three bathrooms?

$ ______

6) There is a proposal that the 1995 Building Code will require a fully ducted, continuous ventilation system. Considering the increases in the air tightness of construction, do you think this proposal is:

a) Necessary? ______

b) Unnecessary? __X__

Comments ______

______

MARKETABILITY OF VENTILATION SYSTEMS

	Easy to Market						Difficult to Market
B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

MAINTENANCE OF VENTILATION SYSTEMS

Easy to Maintain — Difficult to Maintain

B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

AIR QUALITY EFFECTIVENESS OF VENTILATION SYSTEMS

Not Very Effective — Very Effective

B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

POLLUTION CONTROL EFFECTIVENESS OF VENTILATION SYSTEMS

Not Very Effective — Very Effective

B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

INSTALLATION OF VENTILATION SYSTEMS

Easy to Install — Difficult to Install

B.C. Code System	3	2	1	0	1	2	3
HRV System	3	2	1	0	1	2	3

VENTILATION QUESTIONNAIRE

	B.C. CODE VENTILATION		H.R.V. FULL DUCT SYSTEM	
	YES	NO	YES	NO
1) Does it meet air quality needs?	✓		✓	
2) Does it effectively deal with:				
a) Moisture?	✓		✓	
b) Odors?		✓		✓
c) Contaminants?		✓		✓
3) Is it: a) Excessive?		✓	✓	
b) Necessary?	✓			✓

4) Approximately how much does it cost to install B.C. Code Ventilation in an electric baseboard house with three bathrooms?

$600.00

5) Approximately how much does it cost to install an HRV Full Duct System in an electric baseboard house with three bathrooms?

$1800.00

6) There is a proposal that the 1995 Building Code will require a fully ducted, continuous ventilation system. Considering the increases in the air tightness of construction, do you think this proposal is:

a) Necessary? ________

b) Unnecessary? ✓

Comments: The HRV system costs more to operate because of the continuous operation.

MARKETABILITY OF VENTILATION SYSTEMS

	Easy to Market						Difficult to Market
B.C. Code System	3	(2)	1	0	1	2	3
HRV System	(3)	2	1	0	1	2	3

MAINTENANCE OF VENTILATION SYSTEMS

	Easy to Maintain						Difficult to Maintain
B.C. Code System	**(3)**	2	1	0	1	2	3
HRV System	3	2	**(1)**	0	1	2	3

AIR QUALITY EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	2	1	0	**(1)**	2	3
HRV System	3	2	1	0	1	2	**(3)**

POLLUTION CONTROL EFFECTIVENESS OF VENTILATION SYSTEMS

	Not Very Effective						Very Effective
B.C. Code System	3	2	**(1)**	0	1	2	3
HRV System	3	2	1	0	1	**(2)**	3

INSTALLATION OF VENTILATION SYSTEMS

	Easy to Install						Difficult to Install
B.C. Code System	**(3)**	2	1	0	1	2	3
HRV System	3	2	1	**(0)**	1	2	3

APPENDIX 11.

TEST EQUIPMENT

TEST EQUIPMENT

The equipment used in the sampling for this study are as follows:

NOVA 5280 Carbon Dioxide/Carbon Monoxide Analyzer;

BURKE 1000 Micro-processor Control Panel;

Calibrated Air pump/impinger Formaldehyde Monitors;

Advance Controls Technologies) Electronic 5% RH, and Electronic Temperature Sensors;

Sling Psychrometer;

Digital Thermometers;

DWYER 470-1 Thermal Anemometer;

Microbiological & mycological sampling.

APPENDIX 12.

INDOOR AIR QUALITY GUIDELINES

INDOOR AIR QUALITY GUIDELINES

Contaminant	Maximum concentration	Source
Carbon dioxide (Ashrae)	600 ppm to 1,000 (Problems start)	Humans and animal respiration
Carbon Monoxide (Ashrae)	35 ppm for 1 hour 9 ppm annual	Cigarettes, combustion of fossil fuels
Formaldehyde	0.1 ppm instantaneous 3 ppm for 8 hours	Building (ASHRAE) Products, U.F.F.I., glue and particle board
Respirable Particles (OSHA Standards)	0.075 mg/m3 instantaneous RSP Particle size=1.0-10.0um	Dust, smoke, plant spores pollens, bacteria
Micro-organisms (OSHA Standards)	Average particle sizes are as follows: Atmospheric dusts 0.001 -25um Bacteria .3-13um Insecticide dusts 0.5-10um Pollens 10 - 100um Tobacco smoke 0.01-1um Viruses 0.004-0.06um	Products, cloth, rugs, humans, pets humidifiers, plants, insects, air conditioners. Any organic material can support growth when wet.
Bacteria (OSHA Standards)	500 CFU/m3 guideline Generally not a problem e.g. Legionella Pneumophila	Found in buildings in standing water

Contaminant	Maximum concentration	Source
Mycological	Potential fungi of concern: Aspergillus flarus (At high incidence) Aspergillus niger (At any incidence) Aspergillus fumigatus (At any incidence) Stachybotris atra (At any incidence) Thermoactimonyces cadidus (At any incidence)	Any organic material can support growth. Soil, decaying vegetable matter.
Aromatics (OSHA Standards)	In exposure studies, levels of 5mg/m3 or higher were found to cause mucous membrane irritation	Paints, glue varnishes, enamels, carpets, lacquer cleaners, printed paper adhesives, paint strippers plastic, insulation.
- Toluene	200 ppm for 8 hours	
- Xylene	100 ppm for 8 hours	
- Styrene	100 ppm for 8 hours	